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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 173

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. PROFESSIONAL PAPER April 13, 1915

# THE LIFE HISTORY AND HABITS OF THE PEAR THRIPS IN CALIFORNIA

By

S. W. FOSTER and P. R. JONES, Entomological Assistants
Deciduous Fruit Insect Investigations

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WASHINGTON
GOVERNMENT PRINTING OFFICE
1915

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# THE LIFE HISTORY AND HABITS OF THE PEAR THRIPS IN CALIFORNIA.

By S. W. Foster [1] and P. R. Jones,[2] *Entomological Assistants, Deciduous Fruit Insect Investigations.*

## INTRODUCTION.[3]

The so-called pear thrips, (*Euthrips*) *Tæniothrips pyri* Daniel, first attracted attention during the spring of 1902 in a prune orchard near San Jose, Cal. Its injuries rapidly increased in the Santa Clara Valley, and the insect spread to other orchard sections in the San Francisco Bay region. Its increasing destructiveness and spread led to the establishment by the Bureau of Entomology of a laboratory in the Santa Clara Valley to determine the life history and habits of the pest and to determine, if possible, measures for its control in orchards. The laboratory thus started during the summer of 1907 was continued to the fall of 1912.

Mr. Dudley Moulton, an agent of this bureau, who, as Santa Clara County entomologist, had previously had experience with the insect, was placed in immediate charge of the work, in which position he continued until September, 1909. During his period of service Mr. Moulton was assisted in the Santa Clara Valley at one time or another by Messrs. C. T. Paine, S. W. Foster, and P. R. Jones.

In the fall of 1908 owing to the rapid dissemination of the pear thrips to the northward an additional laboratory was established in Contra Costa County, with headquarters at Walnut Creek. This work was placed under the immediate direction of Mr. S. W. Foster, who also had charge of operations in the infested counties to the north. During the spraying season of 1909 Mr. Fred Johnson collaborated with Mr. Foster in experimental and demonstration spraying in

[1] Resigned Oct. 10, 1912.

[2] Resigned Sept. 30, 1912.

[3] By A. L. Quaintance, In Charge of Deciduous Fruit Insect Investigations.

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orchards, and in July of the same year Mr. E. J. Hoddy was assigned to the Walnut Creek laboratory and assisted in certain cultivation experiments at Suisun in the fall of 1909, and with Mr. R. W. Braucher assisted in the demonstration spraying operations at Suisun and Courtland during the spring of 1910. During the spraying season of 1911 Mr. Foster was assisted by Messrs. E. L. Jenne and R. L. Nougaret.

Upon the resignation of Mr. Dudley Moulton Mr. P. R. Jones was placed in charge of operations in the Santa Clara Valley and was assisted during the spraying season of 1910 by Mr. E. L. Jenne and during the spraying season of 1911 by Messrs. A. G. Hammar and W. M. Davidson.

During the spraying season of 1912, owing to the absence from California of Mr. Foster, Mr. Jones was charged with all of the pear-thrips operations in California and was assisted in the work by Messrs. W. M. Davidson and L. L. Scott, located at Courtland, by Mr. R. L. Nougaret at Suisun, and by Mr. E. L. Jenne at Walnut Creek.

The manuscript for the present report has been prepared as follows: All of the data relating to Contra Costa County and counties to the northward have been prepared by Mr. Foster, the senior author. Report of operations in the Santa Clara Valley, as well as much of the life-history matter, has been prepared by Mr. Jones. The remaining chapters were written jointly by Messrs. Foster and Jones.

Especial acknowledgment is due to the supervisors of Contra Costa County and Santa Clara County for their assistance in furnishing facilities for work during the season of 1909, and for supplementing the bureau's funds before the special appropriation from Congress was available. The bureau desires also to acknowledge its obligations to many orchardists in the thrips-infested territory, who placed at the disposal of the Department of Agriculture their orchards and facilities for experimental and demonstration purposes. The success which many orchardists have obtained in the control of the pear thrips by the adoption of the recommendations of the bureau, as well as the large-scale spraying demonstrations which the bureau has conducted, has fully demonstrated the effectiveness and practicability of the methods recommended. Especial acknowledgment is made also to Mr. W. S. Ballard, of the Bureau of Plant Industry of the United States Department of Agriculture, for much valuable assistance and numerous courtesies rendered during the course of the work at Suisun.

The present paper deals with the life history and habits of the pear thrips, the results of experiments and demonstrations with sprays and other remedial operations having been given in Circular No. 131 of the Bureau of Entomology.

## HISTORY.

### LITERATURE.

The first reference in literature to the pear thrips is the original description of the insect by Miss M. Daniels in Entomological News for November, 1904.[1] The type specimens were taken on pear near San Leandro, in Alameda County, Cal., for which reason it was given the common name "pear thrips."

Dudley Moulton,[2] in 1905, published the first account dealing with the economic importance of this species. He described its different stages and the nature and extent of injury caused by it, and included a discussion of its life history. No advice was given as to remedial measures, except that early winter plowing was advocated.

The third reference to the pear thrips in literature was by the same author in Bulletin 68, Part I, of the Bureau of Entomology.[3] This contained practically all that was included in the former publication, with additional information accumulated, making a more complete account of the pest. It was illustrated with appropriate figures of all stages, including the eggs and pupa, which had not theretofore been figured. No successful remedial measures, however, had been determined.

The next publication was also by Moulton, and was issued as Bulletin 80, Part IV, of this bureau.[4] It gave an extended account of the life history of the pear thrips, with recommendations for early fall plowing and cross-plowing, to be followed by spraying in the spring for the adult and an application against the larvæ after the falling of the petals. Tables were given showing the actual number of thrips killed in the plowed as compared with the unplowed areas.

The next account was published as Circular 131 of the Bureau of Entomology,[5] and is a concise abstract of the present paper.

The Journal of the South-Eastern Agricultural College, Wye, Kent County, England, No. 19, for 1910 (published in 1911), contains an article by F. V. Theobald[6] dealing with thrips in general, in which this species receives considerable prominence.

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[1] Daniel, S. M. New California Thysanoptera. *In* Entomological News, v. 15, no. 9, p. 294–295, November, 1904.

[2] Moulton, Dudley. The Pear Thrips (*Euthrips pyri*). California State Horticultural Commission, Publication, Sacramento, 1905. 17 p., 8 figs.

[3] Moulton, Dudley. The Pear Thrips. (*Euthrips pyri* Daniel.) U. S. Dept. Agr., Bur. Ent., Bul. 68, pt. 1, 16 p., 8 figs., 2 pls., June 10, 1907.

[4] Moulton, Dudley. The Pear Thrips and its Control. (*Euthrips pyri* Daniel.) U. S. Dept. Agr., Bur. Ent., Bul. 80, pt. 4, p. 51–66, figs. 13–17, pls. 4–6, Sept. 4, 1909.

[5] Foster, S. W., and Jones, P. R. How to Control the Pear Thrips. U. S. Dept. Agr., Bur. Ent., Circ. 131, 24 p., 14 figs., Jan. 9, 1911.

[6] Theobald, Fred. V. Report on economic zoology for year ending Sept. 31, 1910, p. 57–67, fig. 5, Pls. XXV–XXVIII. *In* Jour. Southeast. Agr. Col., Wye, no. 19, 1911.

Also in 1911 Mr. P. J. Parrott[1] published an account of the appearance of this species in New York State, and in January, 1912, he issued a more extended account of the pear thrips in New York.[2]

### HISTORY IN ORCHARDS AND DISTRIBUTION.

The first reported injury caused by the pear thrips was noticed in the year 1902, in an orchard owned by Judge S. F. Leib and Mr. G. M. Bowman. This orchard was situated in the Berryessa district of the Santa Clara Valley, near San Jose, and consisted chiefly of the Imperial variety of prunes. The injury was noticed at first on about 20 or 30 acres of the 200 acres of orchard, and the cause of the trouble at that time was unknown. In the spring of 1904 every other row of this orchard was top-worked with sugar prunes, chiefly to secure better cross-pollination with the Imperial variety of prunes, the lack of which was supposed to have been the cause of failure of the crops in the past. During a drive through 100 acres of this orchard the fruit buds were observed to be just beginning to show the white tips of the petals, and the prospects seemed excellent for a good crop. When revisiting the place five days later, the owner found to his utter astonishment that the whole orchard had the appearance of having been scorched with fire and that there was not an average of a dozen blossoms to the tree.

The thrips were discovered this same year (1904) in the orchard of Mr. R. K. Thomas, on Cypress Avenue, near Stevens Creek Road, about 7 miles distant in an air line from the Leib orchard. From these two orchards infestation has, with the exception of a few acres, spread all over the Santa Clara Valley and into other valleys surrounding the San Francisco Bay.

No exact information is available as to the first appearance of the thrips in other counties, but many orchardists claim that it has been in Contra Costa County since 1904 and in Solano County at least since 1906. In addition to these centers of infestation in Santa Clara, Contra Costa, and Solano Counties, the insect is now present in considerable numbers in Alameda, Sacramento, Yolo, Napa, Sonoma, San Joaquin, and San Benito Counties. The general area of infestation in California is indicated in the accompanying map (fig. 1).

There have been several reported outbreaks of this species in other parts of the State, notably from the Sierra Nevada foothills near Newcastle and Auburn, near Red Bluff and Anderson in the Sacramento Valley, and from the fruit districts of Tulare and Fresno Counties in the San Joaquin Valley. The species in question, how-

[1] Parrott, P. J. Occurrence of *Euthrips pyri* Daniel in New York State. *In* Science, n. s., v. 34, no. 864, p. 94, July 21, 1911.

[2] Parrott, P. J. The Pear Thrips. N. Y. Agr. Exp. Sta., Geneva, N. Y., Bul. 343, p. 341-366, 4 figs., pls. 30-33 and 1 col. pl., Jan., 1912.

ever, were found to be (*Euthrips*) *Frankliniella occidentalis* Pergande and (*Euthrips*) *Frankliniella tritici* Fitch, neither of which is particularly injurious to deciduous fruits. Reports of injury supposed to have been caused by this species were received from the Rogue River Valley in Oregon, but a critical examination, in 1909, showed no signs of the work of the pear thrips. In the spring of 1910 many larvæ of (*Euthrips*) *Frankliniella tritici* were found, but none of the species under consideration could be obtained.

Not until the year 1911 was the pear thrips positively known to be present in the United States outside of the infested districts of California. However, in the spring of 1911 Mr. P. J. Parrott found it in considerable numbers around Germantown and other points along the Hudson River in New York.[1]

Later in the year specimens of (*Euthrips*) *Tæniothrips pyri* were found among some Thysanoptera which had been collected in the spring by Mr. Parrott in the vicinity of Geneva, N. Y.

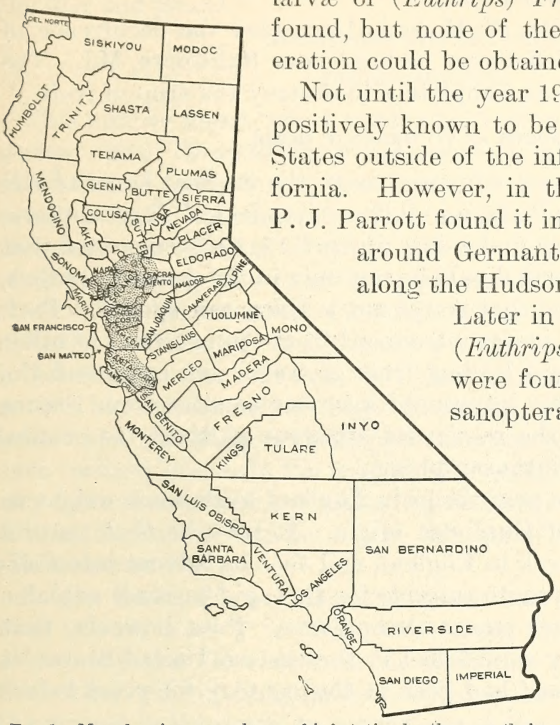



FIG. 1.—Map showing general area of infestation by the pear thrips in California. (Authors' illustration.)

In May, 1912, Mr. A. L. Quaintance sent the authors a number of specimens of thrips collected in pear blossoms from six different orchards by Mr. Fred Johnson at North East, Pa. All proved to be the pear thrips, (*Euthrips*) *Tæniothrips pyri*.

In 1909 Bagnall[2] reported that numerous examples of this very injurious species, taken in plum blossoms at Evesham, England, had been sent to him by Mr. Walter Collinge. So far as we know, this and the previously mentioned account by Theobald are the only published reports of the occurrence of this species outside of the United States.

Two other species of Thysanoptera (*Thrips physapus* L. and *T. flava* Schrank) are mentioned by Carpenter as the "pear-blossom thrips"

[1] Parrott, P. J. Occurrence of *Euthrips pyri* Daniel in New York State *In* Science, n s., v. 34, no. 864, p. 94, July 21, 1911.

[2] Bagnall, Richard S. A contribution to our knowledge of the British Thysanoptera (Terebrantia), with notes on injurious species. *In* Jour. Econ. Biol., v. 4, no. 2, p. 33–41, July 7, 1909.

in his report before the Royal Dublin Society for 1900,[1] and as the "pear thrips" in his report to the same society for 1901.[2] In the report for 1900 he states that these two species were found feeding in unopened pear blossoms near Dublin, and he attributes the failure of the fruit that season to the work of these insects. The report for 1901 states that a Dr. Barton tried a dressing of kainit around the trees, with very satisfactory results.

In December, 1914, Mr. W. M. Scott[3] reported the occurrence of the pear thrips in a Kieffer pear orchard near Baltimore, Md. The insect was so abundant as completely to destroy the crop of fruit.

### THEORIES AS TO ORIGINAL HOME.

Various ideas have been advanced as to the original home of the pear thrips. Dr. Pietro Buffa, a well-known student of Thysanoptera, in private correspondence under date of April 17, 1909, suggested that while it is a good species it should be put only in the genus Physopus, and expressed the belief that it was not a European species. Prof. Silvestri suggested that it was introduced from China or was of other oriental habitat. Several leading fruit growers have expressed the belief that the insect was introduced into this country from France or England, giving as the reason its apparent partiality to prunes, which are varieties of European plums.

The occurrence of the pear thrips in England lends some weight to the theory that it is of European origin. It may be that natural conditions hold it in check in England and that its advent into California under conditions more suitable for its rapid increase explains its presence there in such enormous numbers. Now, however, that its presence is definitely established in the eastern United States, it is probable that the insect had been in this country for years before it was discovered.

It may be possible that the pear thrips is native to the Santa Cruz Mountains, with some wild rosaceous plant as its original food plant. Upon this supposition it is probable that it has been present in the Santa Clara Valley for many years, and that it first became notoriously destructive with the advent of favorable conditions. While this species has been taken upon a great variety of plants and has been found to be able to subsist on many of them, it is distinctly an enemy of deciduous fruits, to which it shows a decided preference.

### COMMON NAMES.

Many common names have been assigned to this insect, as "pear thrips," "prune thrips," "cherry thrips," etc. The first mentioned,

[1] Carpenter, G. H. Report on economic entomology for the year 1900, p. 96–97. Reprinted from the Report of the Council of the Royal Dublin Society for 1900.

[2] Carpenter, G. H. Injurious insects observed in Ireland during the year 1901, p. 153–154. *In* The Economic Proceedings of the Royal Dublin Society, v. 1, pt. 3, no. 5, July, 1902.

[3] Jour. Econ. Ent., v. 7, No. 6, p. 478–479, Dec., 1914.

namely, "pear thrips," has been more extensively used, following the original designation of the insect, because the species was first described from specimens taken upon pear trees. The word "thrips" is a general term for the species of the order Thysanoptera and is sometimes erroneously applied to certain other insects, as the grape leafhopper (*Typhlocyba comes* Say). The word "thrips" is both singular and plural.

## ECONOMIC IMPORTANCE.

### DESTRUCTIVENESS.

This minute insect, which until 1904 was unknown to science, is at present one of the most important insect pests with which the growers of deciduous fruits in the San Francisco Bay region and adjoining counties have to contend. The rapidity with which the insect spreads, its suddenness of attack and complete blasting in a few days of all prospects for a crop of fruit, and the difficulty experienced in its control, combine to make its subjugation a matter of considerable difficulty. Moreover, as the insect is each year developing an ability to subsist on other and new food plants, its capabilities for dissemination become correspondingly increased. There is no reason to believe that the thrips will disappear in a few years, and it should be at once realized that only the most careful attention each year to necessary control measures will make it possible to continue the profitable culture of fruit in regions where this insect is present in any considerable numbers.

In the Santa Clara Valley this insect has been worse some years than others, notably in 1905, 1907, 1908, 1909, and 1910, but it is safe to say that from now on the maximum prune crop possible for this valley will never again be reached unless every orchardist does the utmost in his power to control the thrips. While it may be possible for unfavorable weather conditions to reduce the possibility of a good crop of 100,000,000 pounds of dried prunes for this valley to something like 40,000,000 or 50,000,000 pounds, the thrips, in a great measure, has been responsible for the small crops since 1907, and will continue to be so, first, by killing the fruit buds before they bloom; secondly, by depositing the eggs in the fruit stems, and, thirdly, by the feeding of the larvæ on the fruit, causing it either to drop prematurely or to develop misshapen and scarred on the trees. While the thrips is doing much serious work in the Santa Clara Valley to cherries and pears and the damage done to different varieties of peaches is increasing, yet on account of the small acreage of these fruits the chief loss from a commercial standpoint is to the prune industry. Some idea of the destruction caused by the pear thrips during the previously mentioned bad years may be gained from the following figures, giving the approximate yield of prunes in pounds each year for the years 1900 to 1912, inclusive.

TABLE I.— *Yield of prunes for the Santa Clara Valley, 1900–1912, inclusive.*

| Season. | Yield of dried fruit. | Season. | Yield of dried fruit. |
|---|---|---|---|
| | *Pounds.* | | *Pounds.* |
| 1900 | 120,000,000 | 1907 | 50,000,000 |
| 1901[1] | 35,000,000 | 1908 | 40,000,000 |
| 1902 | 120,000,000 | 1909 | 85,000,000 |
| 1903 | 90,000,000 | 1910 | 35,000,000 |
| 1904 | 100,000,000 | | 40,000,000 |
| 1905 | 50,000,000 | 1911 | 100,000,000 |
| 1906 | 120,000,000 | 1912 | 65,000,000 |

[1] Severe frost.

In 1911 the pear thrips probably caused a heavy loss in spite of the fact that there were not more than one-half as many thrips present in this valley as in 1910. The good prune crop in the Santa Clara Valley in 1911 was due to light thrips injury and the very heavy rainfall. The amount of rainfall, which was about 8 inches more than the normal, not only placed the trees in excellent shape to bear a heavy crop, but, coupled with other climatic conditions during the early part of 1911 and latter part of 1910, lessened the work of the thrips very materially. Notwithstanding a favorable fruit year from a weather point of view, thrips in some places caused a great amount of damage. The thrips damage in the Santa Clara Valley for 1910 was caused principally by the adults, with very little larval work, while for 1911 it was just the reverse, the adults doing comparatively little injury because of less numbers and strong fruit buds as a result of the heavy winter rains. The scarcity of adult thrips in 1911 may have been due to several causes. Two heavy rains during the early part of April of the previous year knocked off many young larvæ before they were sufficiently mature for transformation. In addition the season for pupating, June to December, 1910, was abnormally dry, showing a deficiency in rainfall of 5.28 inches, while the emergence period in the spring of 1911 was unusually wet and cold. All of these conditions caused a higher mortality than would be the case under normal conditions. However, in orchards which showed comparatively few adults the larvæ were sufficiently abundant to riddle the foliage and cause much of the young fruit to drop. The heavy rains during the emergence period also checked to some extent the work of the adults.

In estimating the economic loss to the fruit industry of California caused by the pear thrips it is necessary to begin with the year 1904, when it was first known that the insect was doing commercial damage, and continue down to the present time. An attempt will be made to give a fair estimate of the amount of damage done yearly to the prune industry alone in the Santa Clara Valley for the years 1904 to 1911, inclusive.

The average size of prunes grown in the Santa Clara Valley is 60–70; that is, dried prunes requiring from 60 to 70 to make a pound. The price paid for prunes during the years from 1904 to 1911, inclusive, was variable, but would average close to a 3-cent basis; that is, 3 cents per pound for dried prunes running 80 prunes to the pound. In order to be conservative, the average size, 60–70, is disregarded, and the loss is figured on the regular 80-to-the-pound basis. In 1904 the loss was estimated at 500 tons, or 1,000,000 pounds (dried prunes), which, at 3 cents per pound, amounts to $30,000. For the year 1905 it was placed at 10,000,000 pounds and the damage at $300,000; in 1906 at 5,000,000 pounds, worth $150,000; in 1907, 15,000,000 pounds, worth $450,000; in 1908, 20,000,000 pounds, worth $600,000; in 1909, 30,000,000 pounds, worth $900,000; in 1910, 40,000,000 pounds, worth $1,200,000; and in 1911, 20,000,000 pounds, worth $600,000. The total of all of these years would be 141,000,000 pounds, valued at $4,230,000.[1] The estimates for some years probably have been close to the actual damage done, but more frequently the loss has undoubtedly been underestimated. In 1904 all the fruit of one orchard, comprising 100 acres of Imperial prunes, was totally destroyed, and this alone at an average crop of 5 tons of green prunes per acre, on a 3-cent basis for dried prunes, would have been valued at close to $30,000, because of the large size of this variety of prune, only from 30 to 40 of which make a pound.

In estimating this loss no account is taken of the great depreciation in value of the crop caused by scabbing. The entire yield each year has been counted as merchantable fruit, and estimates of damage made solely from orchards showing total loss or a marked reduction in tonnage produced.

To explain more fully the commercial quotation of a 3-cent basis, it is meant that 3 cents per pound will be paid for dried prunes averaging 80 prunes to the pound. For prunes which are larger and free from scab or defects the price is usually $1 per ton more for each point in size, and for smaller prunes the price decreases correspondingly.

As to the extent of the damage the pear thrips will cause in this county if left unchecked, it is difficult to estimate, but the fact that thrips were twice as numerous in 1910 as in 1909 shows their ability to double the damage performed in any preceding year. The cause for the notably light prune crop in 1910 is not attributed altogether to the work of the pear thrips, but partly to unfavorable weather conditions, which pervented many of the blossoms from setting fruit. However, all the large producing prune districts of the Santa Clara Valley were very seriously injured by the pear thrips, and hundreds

[1] These estimates are based on fuller and more complete reports than could be obtained in time for Circular 131 of the Bureau of Entomology, and these figures more nearly represent the actual loss.

of acres in these districts were prevented from blooming—a fact not attributable to unfavorable weather conditions but solely to ravages of the thrips. Other orchards, under same weather conditions but with little or no thrips injury, produced a full crop of blossoms.

During the year 1911 another type of injury that was different from previous years, which may be called cumulative injury, was noticeable in many orchards. Barring the three heavy frosts in April, the blooming and fruiting season in 1911 was exceedingly favorable in so far as climatic conditions were concerned. Nevertheless about the 1st of May the trees in many orchards turned a sickly yellow owing to the work of the thrips in 1911 and from devastations by this insect in previous years. Some orchards which were out of the frost belt and which were not severely injured by thrips in 1911 showed this condition noticeably. It is possible that much of this was due to neglect of the orchards by fruit growers who did not obtain crops of fruit during the preceding four years because of the injury of the thrips to the buds, blossoms, and young fruit.

As mentioned before, practically all of the Santa Clara Valley came into full bloom in 1911 and gave promise of a record crop, but larval injury was very heavy over the entire valley. This, with the result of injury in previous years, apparently greatly weakened the trees and caused much of the fruit to fall at the first unfavorable weather.

Injury to pears in the Santa Clara Valley has never risen to great proportions from a financial point of view, for the reason that most of the acreage of this kind of fruit is set out near Santa Clara and Alviso, sections of this valley where the thrips has not yet become dangerously numerous. However, during the season of 1911 a number of orchards in these localities became badly infested. The amount of damage done to cherries in this valley has not been determined on account of the scattered acreage planted to cherries in the infested area.

The distinctly severe years for thrips injury in Contra Costa County in pear orchards were 1908 and 1910, when the crops were practically annihilated. Also there was great loss the two previous years, 1906 and 1907. The prune orchards suffered in these years and in the year 1909, producing less than one-third of a normal crop any one year. The fruit crop has been seriously menaced each year since 1905, the area increasing yearly, and in 1911 it aggregated a total loss to the county of between $1,000,000 and $1,250,000.

Solano County has in some ways been more fortunate, as the thrips has been known to cause serious injury only since 1907, but even in that time the thrips has spread rapidly and caused great damage on large areas; the damage in 1911 was very extensive and the total

loss to the county attributable to the work of the pear thrips amounted to at least $750,000.

The damage in Sacramento County was noticeable only in a comparatively limited area in 1909, increasing considerably both in area and destructiveness during 1910 and 1911, and the total loss to that county probably amounted to at least $250,000.

No accurate figures are available for the damage caused in Alameda County, but a considerable area has been infested for several years and many conservative estimates put the total loss to, but not including, 1912, as more than $150,000.

The pear thrips has more recently been found in slightly injurious numbers in Yolo and Napa Counties, in the eastern part of Sonoma County, in the northwestern part of San Joaquin County, and in some parts of San Benito County.

Including the infested areas in Santa Clara, Contra Costa, Solano, Sacramento, Alameda, Yolo, Napa, and Sonoma Counties, it is safe to say that the thrips, in absence of treatment, would cause an average yearly loss of over $2,000,000. With each additional year an additional loss of several hundred thousand dollars, due to the increase of the area infested and the increased losses in the areas previously infested, is to be expected. The total damage to the fruit industry of the State of California since the first appearance of the insect aggregates, it is believed, at least $6,630,000 up to but not including 1912.

### FOOD PLANTS.

While the pear thrips is distinctly a deciduous-fruit insect and practically all of its damage is confined to this class of plants, it has been found upon a great variety of plants the list of which is increasing each year. The fact of its wide range of food plants makes extermination practically impossible, whereas control can be readily practiced. It has been taken upon the following plants and could probably subsist upon a number of them long enough to make it a constant menance to the fruit industry of California: Apricots, apples, almonds, cherries, figs, grapes, pears, plums, prunes, walnuts, madroña (*Arbutus menziesii*), wild California lilac (*Ceanothus thyrsiflorus*), poison oak (*Rhus diversiloba*), dogwood (*Cornus* sp.), acacia, willow (*Salix* sp.), laurel (*Umbellularia californica*), mustard (*Brassica nigra*), live oak (*Quercus wislizeni*), miner's lettuce (*Montia perfoliata*), and various grasses and weeds.

## CHARACTER OF INJURY.

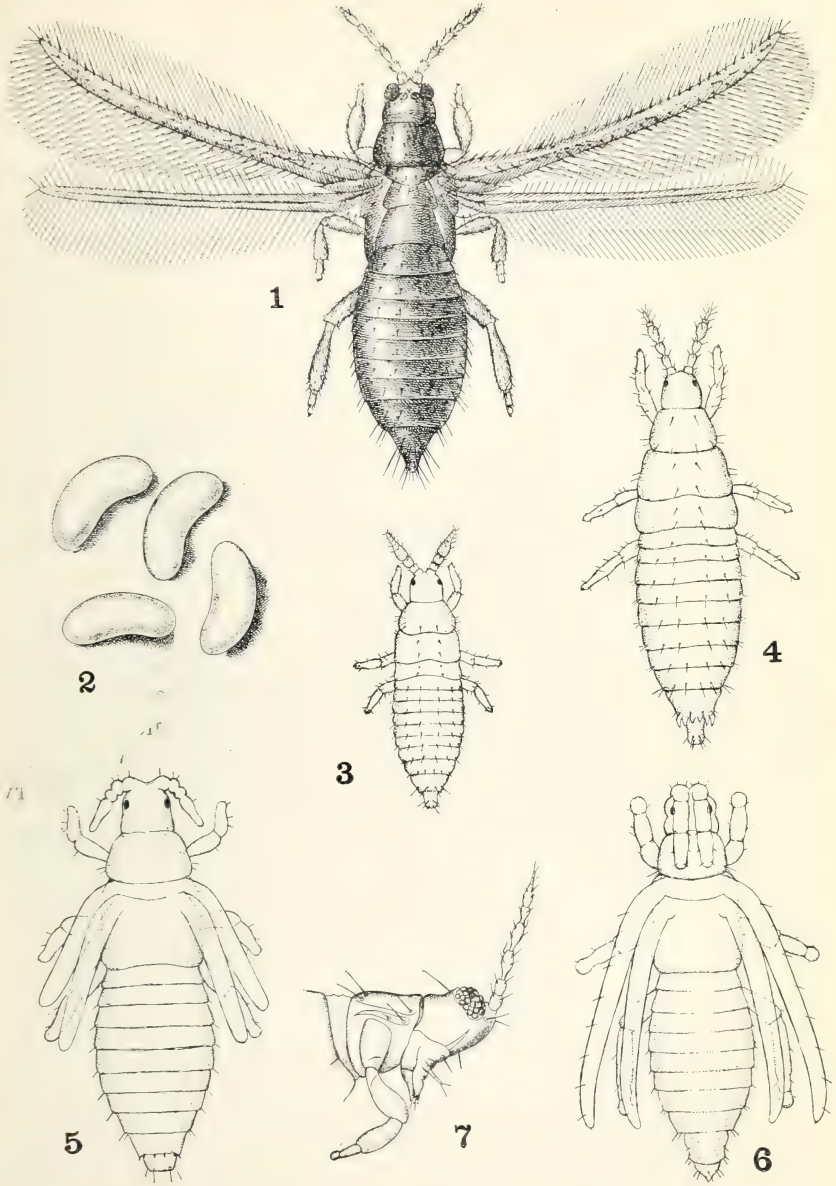
### MANNER OF FEEDING AND TYPE OF MOUTHPARTS.

Injury to plants by the pear thrips is caused directly by the feeding of the adults and larvæ upon the various portions of the fruit, buds, flowers, and leaves, and also by the deposition of eggs in the leaf surfaces, fruit stems, and newly formed fruit.

The mouthparts of the Thysanoptera present many difficulties for study and are not thoroughly understood. They are so modified that various writers have disagreed regarding their homologies. They appear, however, to belong chiefly to the suctorial type, and they show many traces of a transition from the mandibulate type to the suctorial. (See Pl. I, fig. 7.) Viewed as a whole, the mouthparts appear as a broad and jointed cone attached to the posterior edge of the underside of the head and resting for a large part under the pronotum. The apex of the cone is quite sharp, but not so slender and drawn out as in the Hemiptera. The mouthparts as a whole are strikingly unsymmetrical. The most evident marks of this are the forms of the labrum and the left mandible. The first, which makes the front wall of the cone, is unsymmetrical in the whole order, but especially so in the Terebrantia. It is irregularly triangular in form and is attached by its broad base to the clypeus. It becomes narrower as it approaches the tip and is usually rounded in the Terebrantia but more variable in the Tubulifera, where it is pointed in some species and broadly rounded in others. The maxillæ are broad and flat and constitute the side walls of the mouth cone. They also taper toward their tips. The labium forms a hind wall of the mouth cone and is usually considerably broader at the tip than at the other parts. Within this hollow cone lie the piercing organs, which are three in number. First, there is a single large mandible lying on the left side of the mouth cavity, whereas the right side has no corresponding member.[1] The other two organs are the maxillary lobes. These are more slender and longer than the mandibles and are developed alike on each side. All of the mouthparts are strongly chitinized at the tip, being more so in the adults than in the larvæ although the mouthparts of the latter are otherwise closely similar to the former.

The members of this order are thought to use the mandibles for piercing the exterior portion of the plants, while the maxillary lobes, which are longer, are used to penetrate deeper into the tissues, and are moved with a rasping motion, causing the juices of the plant to flow, so that they may be sucked up into the alimentary canal. In feeding, as observed by aid of a hand lens, both adults and larvæ exhibit an up-and-down motion of the head combined with a forward motion which might be properly termed rooting. Most of the species under the writers' observation prefer to enlarge a wound into the plant tissues where the juices flow more readily rather than to select new areas for feeding. This continual macerating of the fruit by the pear thrips for a period of several days causes on deciduous fruits what is known as the characteristic pear-thrips scab, which

[1] The mandible in the Tubulifera is shorter and more bent than in the Terebrantia.




THE PEAR THRIPS (TAENIOTHRIPS PYRI DANIEL).

FIG. 1.—Adult. FIG. 2.—Eggs. FIG. 3.—First-stage larva. FIG. 4.—Full-grown larva. FIG. 5.—Pupa, first stage. FIG. 6.—Pupa, last stage. FIG. 7.—Side view of head showing mouth parts. All greatly enlarged. (Original.)

FIG. 1.—MATURE PEAR SHOWING INJURY RESULTING FROM FEEDING OF LARVÆ OF THE PEAR THRIPS. (ORIGINAL.)

FIG. 2.—TOMATO-SHAPED PEARS RESULTING FROM FEEDING BY ADULT PEAR THRIPS IN THE FRUIT BUDS BEFORE BLOOMING. (ORIGINAL.)

INJURY TO PEARS BY THE PEAR THRIPS.

is very noticeable when the fruit is picked in the fall. Although at this time the insects in question have been in the ground three or four months, the injury becomes more apparent with the maturity of the fruit, and the scabbing or scarring shows as the result of the early spring feeding by this species.

The most serious injury to deciduous fruits by the pear thrips is caused, first, by the feeding of the adults; secondly, by the feeding of the larvæ, and thirdly, by the deposition of eggs in the plant tissue by the adults. The effect of this last injury is more apparent upon the fruits of prunes and cherries than upon the other deciduous fruits. Numerous cases have been observed by the writers in both prune and cherry orchards where the trees blossomed heavily and there was promise of the setting of a good crop of fruit, but where practically all the fruit dropped, solely from the effect of having too many eggs deposited in the fruit stems, thus weakening the tissues, and because the larvæ, feeding directly on the fruit and foliage, so weakened the tree that it would not support a heavy crop of fruit. Perhaps the chief injury to cherries is caused by the deposition of eggs in the fruit stems. The long and tender stem of the cherry presents a most favorable place for the deposition of a great number of eggs.

Injury to the various fruits by adults and larvæ is different, but, classed in regard to bud structure, those fruits in which only a single blossom is produced in a fruit bud, such as the almond, apricot, and peach, seem to be less liable to severe injury than are the fruits which which form a cluster of blossoms amd later produce a cluster of fruits, such as pear, prune, cherry, and apple. If the thrips had their choice of food plants, pears would probably be attacked first in the spring and destroyed; also, other things being equal, a given number of thrips would do more injury no doubt in a pear orchard than in a cherry or prune orchard.

### INJURY TO PEARS.

The greater injury to pears is caused by the feeding of the adults in the bud clusters before blooming. Coming out of the ground in great numbers in the spring as the fruit buds are swelling, the thrips soon work their way underneath the bud scales and there attack the individual buds. The feeding is not a biting and chewing process, but the thrips, by rasping the tender surfaces in the developing buds with their hardened or chitinous mouthparts, rupture the skin, and the exudation of sap begins. If only a few thrips are present this injury may be slight and the buds may develop and bloom, producing fruit of normal size, although sometimes short-stemmed, or scarred and misshapen. (See Pl. II, fig. 1.) Plate II, fig re 2, shows two Bartlett pears which grew from a cluster that was badly injured but

not entirely destroyed. Plate III, figure 1, shows a mature Bartlett pear the one-sided appearance of which was caused partly by adults and partly by larvæ. When thrips are more numerous a greater amount of the bud surface is injured, consequently there is a greater loss of sap. If this loss is sufficient to cause the cluster buds to "bleed" (sap to drop from the end), fermentation quickly sets in and the entire cluster is soon destroyed. (See fig. 3, in comparison with fig. 2, which shows the cluster buds developing normally.) In many cases blue molds gain a foothold in this fermenting sap and greatly accelerate the injury, causing complete destruction of all fruit buds. The dead clusters later dry up without opening. (See Pl. III, fig. 1, and compare it with Pl. III, fig. 2, which is from a photograph of the sprayed portion of the same orchard, taken on the same day.) These dead buds may remain on the trees for months unless washed off by rain or blown by winds. The writers have seen many orchards so severely injured that it was difficult to find a single healthy blossom, and the entire orchard from a distance presented at blossoming time a brownish color and dead appearance, due to these blasted buds.

FIG. 2.—Cluster buds of Bartlett pears developing normally. (Original.)

Weather conditions influence to a great extent the destruction following the injury caused by the thrips. For instance, the weather of 1909 in the interior valleys during late February and the first 20 days of March was open and comparatively dry, with more or less wind blowing, giving quick evaporation throughout the day. Many clusters of buds that were kept under observation throughout the season, with from 10 to 20 thrips in the cluster, developed many of their buds and produced fruit, a large percentage of which was first class. During this period for 1910 there was considerable rain and the atmosphere was warm and humid with very light evaporation. From many observations in Contra Costa and Solano Counties it was shown conclusively that in every case where as many as 10 to 15 thrips

gained entrance into the bud cluster early in the season, and were left unmolested, the entire cluster was sufficiently injured to prevent the appearance of a single blossom. In 1909 there was greater evaporation, comparatively little of the characteristic bleeding showed at the tips of the buds, and far less of the blue molds appeared in any place. Also the thrips came out of the ground more slowly than in 1910. The latter year thrips were held back to a slight extent by cold wet weather, but once the emergence from the ground commenced, thrips came very rapidly. Then, too, they were more numerous throughout the entire section in 1910 than they were the previous year.

FIG. 3.—Work of the pear thrips on pear at San Jose, Cal. (Original.)

The serious nature of this insect can be understood when it is realized that in a badly infested pear orchard it is far more usual to find from 75 to 150 and often as high as 200 thrips to the cluster than only 10 to 15. Any spraying to be effective must be done before these thrips have remained long, in numbers, inside the bud clusters. A delay of four or five days in spraying the badly infested orchards in the spring of 1910 meant the loss of the entire crop, and in many cases a delay of two to three days for the first application meant a loss of more than half the crop.

In the ability completely to destroy the crop the adult is of more importance than the larva, and in many large orchards the destruction of the developing fruit buds by the adults has been so complete that by the time the trees would normally come into bloom there was left no possibility for a crop of fruit. The larva, together with the injury which has been caused by the deposition of the eggs by the adult, can lessen the prospects of a good crop of fruit after it has apparently set. To secure the best results it is always desirable first to apply efficient treatment against the adult in order to reduce the early injury to a minimum so that the trees may bloom, and later, to make additional treatment against the larvæ. This will usually result in increasing the value of the crop from 10 to 25 per cent for

pears and 40 to 50 per cent for prunes. If remedial measures are not successfully used against the adult but only against the larvæ, it is not to be expected that 50 per cent of a crop will be saved; but the additional treatment against the larvæ after the adult treatments have been applied will cause from 10 per cent to 50 per cent more of the crop to remain on the trees. Without taking into account the after effects of migration, good results can be had in pear orchards by spraying against adults alone, if thorough work is done at the proper time.

### INJURY TO PRUNES.

Next to the pear, thrips injure prunes most severely; and, as the larger fruit area in the Santa Clara Valley is devoted to this kind of fruit, and since the pear thrips has caused the failure over large areas of the prune crop for several years, growers in the Santa Clara Valley have commonly called this particular species the prune thrips. The large acreage of prunes and the general distribution of the pear thrips over the valley, together with the fact that the majority of the thrips are out before many of the buds of the French prunes have started to spread, make it very evident that these little insects, which are waiting on the outside of the twigs in enormous numbers, will at the first sign of life of the prune buds bury themselves into the very heart of the tenderest parts, and rapidly carry on their work of destruction. The numbers that will get inside of a prune cluster is really astonishing. Many times the writers have, from a single cluster, taken more than a hundred of these little insects feeding upon the tender blossom stems, the tips of the petals, and the stigma and style of the blossoms when they have opened. These parts mentioned seem to be the choice bits for the adults when feeding upon the prunes. The rapidity with which the thrips can destroy the whole year's crop is astonishing. Many a time orchardists have gone into their prune orchards at the time the buds were about ready to spread, and, with only casual observation, have failed to see these minute, dark-colored insects crawling around or at rest upon the twigs and buds. Upon inspecting the orchard four or five days later, expecting it to be in full bloom, they have been astounded to find practically all the buds destroyed, leaving no hope for a crop that year, the entire orchard presenting a brown, burnt appearance, with only a stray blossom now and then, a sight which is well known now to the majority of the prune growers of the Santa Clara Valley. Anyone who has ever seen one of these prune orchards with the burned, browned, and blasted appearance beside another of snowy whiteness will never forget the contrast. (See Pl. IV, comparing fig. 1 with fig. 2.) Again there may be a very severe larval injury on prunes, such as was the case in 1911. Very few adult thrips occurred in comparison with

FIG. 1.—UNTREATED PORTION OF PEAR ORCHARD, SHOWING LOSS OF PEAR BLOSSOMS RESULTING FROM ATTACK OF THE PEAR THRIPS. (ORIGINAL.)

FIG. 2.—SPRAYED PORTION OF SAME ORCHARD, SHOWING TREES IN BLOSSOM. (ORIGINAL.)

INJURY TO PEAR ORCHARDS BY THE PEAR THRIPS.

FIG. 1.—UNSPRAYED PORTION OF PRUNE ORCHARD IN WHICH BLOSSOMS ARE COMPLETELY DESTROYED BY THE PEAR THRIPS. (ORIGINAL.)

FIG. 2.—SPRAYED PORTION OF THE SAME ORCHARD, SHOWING TREES IN FULL BLOSSOM. (ORIGINAL.)

INJURY TO PRUNE ORCHARD BY THE PEAR THRIPS.

FIG. 1.—PRUNES SCABBED AS A RESULT OF FEEDING BY PEAR THRIPS LARVÆ. (ORIGINAL)

FIG. 2.—NORMAL FRUIT, UNINJURED BY THE PEAR THRIPS. (ORIGINAL.)

PRUNES INJURED AND UNINJURED BY PEAR THRIPS LARVÆ.

1910, and they did not accomplish much injury in the Santa Clara Valley, but larvæ were present in large numbers everywhere and riddled the foliage (fig. 4) and weakened the fruit stems, making the financial loss amount to about half as much as in 1910.

In regard to varieties, Imperial prunes seem to be attacked first and injured, on the whole, more severely than French prunes in the Santa Clara Valley. This may be explained in several ways: For one thing, the acreage of this variety in the Santa Clara Valley is much less than that of the French prunes and the blossoming period is usually about a week or more earlier; then, too, the small develop-

FIG. 4.—Prune foliage riddled by pear thrips larvæ. (Original.)

ing fruit stems of the Imperial prunes seem to be more tender and not so able to withstand the attacks of the thrips as are those of the French prunes. Sugar prunes, which blossom at a period intermediate between the blossoming periods of Imperial and French prunes, are, from a financial standpoint, not injured so greatly as are either of the other varieties. This is partly due to the fact that this variety sets an unusually large amount of fruit and is therefore able to withstand the loss of a considerable portion of it and still produce a fair crop. The scabbing of the prunes on this variety, however, is often so deep as to cause a large exudation of gum and to render a large

portion of the fruit unmarketable. Plate V, figures 1 and 2, shows photographs of sprayed and unsprayed prunes, the prunes having been picked from trees when full grown. Robe de Sargent prunes blossom about the same time as French prunes, and are injured to the same extent as that variety.

### INJURY TO CHERRIES.

Cherries, as a whole, are not injured so severely by the feeding of a given number of adults as would be the case for the same number of thrips upon pears and prunes, but certain varieties, especially the black cherries, suffer comparatively as much from a monetary standpoint as either pears or prunes. Probably the worst damage accomplished on cherries is by the deposition of eggs in the long fruit stems and in the leaves, and by the feeding of the larvæ upon the foliage. The deposition of eggs in the fruit stems has at times caused a large percentage of the cherry crop to drop, and it is a common sight to see the foliage entirely riddled by the larvæ, thus greatly weakening the trees. Many other instances are on record where the adults have injured the fruit buds to such an extent that only a few blossoms appeared. Late varieties of cherries, such as the Royal Anne, escape serious injury more than the earlier blooming black varieties. Fortunately the manner of bud growth and blossoming of cherries permits effective penetration of different spray solutions more advantageously than is the case with either pears or prunes.

### INJURY TO APPLES.

While there are not many instances of great commercial injury to apples, yet individual cases have been known where the adult thrips have killed all of the buds in the cluster except the central one. This was especially noticeable in an orchard of the Newtown Pippin variety in the vicinity of San Jose in 1910. Some small orchards in Sacramento County were rather seriously injured during the same year.

### INJURY TO PEACHES.

Following the apple, peaches come next in importance as regards possibility of dangerous injury, the early varieties suffering the greater loss. The more seriously injured varieties are the Muir, Nicol-cling, Crawford, Foster, and Lovel, in order of damage done, injury being more severe on the first two varieties mentioned. On account of the hairy pubescence on the young peach fruits, the thrips prefer to feed upon the nectary glands and the inside of the calyx cups; this prevents proper pollination, and the young fruits drop to the ground a few weeks after the blossoming period. Where the injury has been severe, peaches are sometimes prevented from blooming, and the larvæ feeding upon the tender leaves cause them to curl and become dis-

torted somewhat in the same manner as does peach leaf-curl. Sometimes the larvæ feed on the young fruit, but rarely to the extent of causing any great loss.

### INJURY TO APRICOTS.

Apricots have not, as a rule, been injured commercially except in cases where there are a few young trees around home grounds or near an infested pear or prune orchard. They are sometimes injured to about the same degree as peaches, and in some cases isolated trees have been observed which failed to bloom as a result of the work of the thrips. Larval injury to the young fruit is usually more extensive than is the case with peaches and may at times be serious. However, apricots are apparently not favorite breeding places for thrips.

### INJURY TO ALMONDS.

Almonds are injured less by the thrips than any of the foregoing fruits. On account of the early blossoming of the trees and the relatively greater amount of exposed leaf surface at the time the thrips are out in numbers, together with the character of the blossom, which is similar to that of the peach, feeding by the thrips very rarely causes much commercial loss in almond orchards.

## DESCRIPTION.

### EGG.

The egg when first deposited is bean-shaped, translucent white, measuring on the average about 0.416 mm. in length and about 0.166 mm. at its widest part in the middle. (Pl. I, fig. 2.)

Just before hatching it decreases in length, appears swollen, has a slight brownish tint, and is faintly striated longitudinally where the antennæ and legs are folded together. The dark brown spots, the eyes of the young larva, are apparent at one end.

### LARVA.

#### FIRST STAGE (LARVA 1 DAY OLD).

Length 0.646 mm.; width of head 0.166 mm.; width of mesothorax 0.183 mm.; width of abdomen 0.15 mm.; length of antennæ 0.2 mm.; length of antennal segments: I 20$\mu$, II 40$\mu$, III 45$\mu$, IV 100$\mu$. General color translucent white. General shape fusiform. Antennæ, head, and legs large in proportion to the rest of the body, and unwieldy. Antennæ distinctly four-segmented, first segment short, cylindrical; second segment about twice as long as first, oval cylindrical; third segment slightly longer than second, urn-shaped; fourth about as long as rest of joints together, acutely conical. A few very fine inconspicuous hairs present on all joints, more prominent on segment 4; Head subquadrate; eyes reddish brown. Thorax about as long as abdomen, slightly wider. Abdomen gradually tapering, 10-segmented, first eight segments subequal, IX and X longer and more abruptly tapering, with a fringe of long, white, nearly inconspicuous hairs. Legs stout; femora and tibiæ nearly equal in length; tarsi one-jointed, ending in a single black claw. (Pl. I, fig. 3.)

SECOND STAGE (FULL-GROWN LARVA).

Total length 1.833 mm.; length of head 0.15 mm., width 0.1083 mm.; length of prothorax 0.1833 mm., width 0.2166 mm.; length of mesothorax 0.1833 mm., width 0.466 mm. Length of antennæ 0.2833 mm.; segment I 26$\mu$, II 50$\mu$, III 76$\mu$, IV 66$\mu$, V 14$\mu$, VI 16$\mu$, VII 33$\mu$. Antennæ: Segment I short cylindrical; II obtuse spindle-shaped; III spindle-shaped, about as long as I and II together; IV nearly as long as III, broader than the rest, subconical; V short, narrow cylindrical; VI slightly narrower and longer than V; VII twice as long as VI, narrower and cylindrical. All joints transversely striated and with a few inconspicuous white hairs. General color faintly yellowish white, obtusely fusiform in shape. Body longitudinally and laterally faintly striated. Head quadrate; eyes prominent, dark reddish brown, situated a little in advance of the middle; mouth cone broadly rounded, nearly as long as the head, extending to the middle of the prosternum. Prothorax large, slightly wider than long, diverging posteriorly. Mesothorax and metathorax short and broad, twice as wide as long, subequal, in length about as long as prothorax. Abdomen broad, gently rounded, 10-segmented, broadest at segments V and VI; first eight segments subequal; segment IX distinctly longer, tapering to apex, the posterior edge armed with a circle of strong, short, thick wedge-shaped spines, the two mediodorsal and medioventral ones shorter and smaller; segment X slightly tapering, not quite as long as segment IX. Lateral edges of abdomen finely serrated, also with a few long inconspicuous white hairs which are more prominent on segment X. Legs strong; femora and tibiæ about equal; tarsi one-jointed, ending in a single black claw. (Pl. I, fig. 4.)

NUMBER OF MOLTS; DEVELOPMENT.

When first hatched the larvæ are active and start feeding immediately and soon become more robust. At the end of about seven to eight days they molt into second-stage larvæ, where (see description) they are still more robust and show also other differences. The total time required for the development of the larvæ is about three weeks, although this period is shorter during warm weather.

PUPA.

PREPUPA (FIRST STAGE).

Total length 1.333 mm.; length of head 0.1 mm., width 0.116 mm.; length of prothorax 0.183 mm., width 0.266 mm.; width of mesothorax 0.35 mm.; length of abdomen 0.666 mm., width 0.383 mm. Shape similar to adult; color translucent white, deeply tinted with brown. Head subquadrate, about as broad as long, eyes dark reddish brown. Mouth-cone broadly rounded, extending to about one-half length of the prosternum. Antennæ extending backward on each side of head, apparently four-jointed; first three segments nearly subequal in length, about as broad as long, thick and unwieldy; segment IV about as long as remaining joints, clublike, and tapering to an obtuse point. Antennæ with a few inconspicuous white hairs. Prothorax nearly twice as long as the head, broadly rounded posteriorly. Mesothorax broader; wing pads short, those of first pair of wings extending to distal edge of third abdominal segment. Abdomen 10-segmented, widest at III and IV, segments gradually tapering from there posteriorly. First eight segments subequal, IX and X longer, distal end of IX with broad spines somewhat similar to those of second-stage larvæ but shorter and smaller. Legs stout, similar to those of full-grown larva, whole body with sparse, light-colored, inconspicuous hairs. (Pl. I, fig. 5.)

PUPA (SECOND STAGE).

Total length 1.416 mm.; length of head 0.183 mm., width, 0.166 mm.; length of prothorax 0.166 mm., width 0.25 mm.; width of mesothorax 0.35 mm.; length of abdomen 0.783 mm., width 0.416 mm. Shape similar to adult, which is visible beneath the thin transparent shell. Apparently brownish in color, caused by adult within. Head broader than long; eyes large, dark brown; mouth-cone of adult within extending to posterior edge of prothorax. Antennæ large, cumbersome, laid back on the head and extending past middle of prothorax, four-jointed; I short; II elbowed, about twice as long as I; III short, cylindrical; IV longer than III, sides uneven as knotted club gently tapering to obtuse apex. Joint I of adult is in joint I of pupa, joint II of adult in joint II of pupa, and III of adult within III of pupa; remaining joints of adult within IV of pupa; 3 or 4 white, inconspicuous hairs projecting cephalad from elbow on joint II. Prothorax broader than long. Mesothorax about one and one-half times as broad as prothorax. Wing-pads extending to distal margin of eighth abdominal segment, fore pair not quite so far. Abdomen widest at third and fourth segments, tapering from there to obtuse apex. Posterior edge on ventral side of segment IX with four strong spines resembling a meat fork. This is apparently the cremaster. Legs stout. Entire body with numerous inconspicuous white hairs. (Pl. I, fig. 6.)

ADULT.

Length of head 0.13 mm., width 0.15 mm.; length of prothorax 0.13 mm., width 0.2 mm.; width of mesothorax 0.28 mm.; width of abdomen 0.31 mm.; total length 1.26 mm. Length of antennal segments: I 33$\mu$, II 45$\mu$, III 63$\mu$, IV 54$\mu$, V 33$\mu$, VI 66$\mu$, VII 9$\mu$, VIII 12$\mu$, total 0.31 mm. Color dark brown; tarsi light brown to yellow. Head slightly wider than long, cheeks arched, anterior margin angular, back of head transversely striate and bearing a few minute spines and a pair of very long prominent spines between posterior ocelli. Eyes prominent, oval in outline, black with light borders, coarsely faceted and pilose. Ocelli approximate, yellow, margined inwardly with orange-brown crescents, the posterior ones approximate to, but not contiguous with, light inner borders of eyes. Mouth-cone pointed, tipped with black; maxillary palpi three-segmented; labial palpi two-segmented, basal segment very short. Antennæ eight-segmented, about two and one-half times as long as head, uniform brown except segment III, which is light brown; spines pale; a forked sense-cone on dorsal side of segment III, with a similar one on ventral side of segment IV. Prothorax about as long but wider than head; a weak spine at each anterior and two large, strong ones on each posterior angle; other spines not conspicuous. Mesothorax with sides evenly convex, angles rounded; metanotal plate with four spines near front edge, inner pair largest. The mesonotal and metanotal plates are faintly striate. Legs moderately long, uniform brown except tibiæ and tarsi, which are yellow. Spines on tip of fore and middle tibiæ weak; several strong spines on hind tibiæ. Wings present, extending beyond tip of abdomen, about twelve times as long as wide, pointed at tips; costa of forewings thickly set with from 29 to 33 quite long spines; fore vein with 12 to 15 arranged in two groups of 3 and 6, respectively, on basal half of wing and a few scattering ones on distal part; hind vein with 15 or 16 regularly placed spines; costal fringe on fore wing about twice as long as costal spines. Abdomen subovate, tapering abruptly toward the tip from the eighth segment; longest spines on segments 9 and 10; abdomen uniform brown, connective tissue yellow. (Pl. I, fig. 1.)

## SYSTEMATIC POSITION.

The pear thrips belongs to that suborder of the Thysanoptera called Terebrantia, which differs from the other suborder, the Tubulifera, in the possession by the female of a sawlike ovipositor; also, the terminal segments of the abdomen are conical and the wings are not equal in structure, the fore pair being the stronger. The membrane of the wings, also, has microscopic hairs. This species is placed in the family Thripidæ and is separated from the Æolothripidæ in that the antennæ usually have from 6 to 8 segments, the wings usually are narrow and pointed at the tips, and the ovipositor is downcurved. It is placed in the genus Tæniothrips of this family because the body is free from reticulation and the abdomen not closely pubescent; the head nearly or quite as long as wide, with a pair of long bristles between the anterior and posterior ocelli; the cheeks swollen, curving abruptly to the strongly protruding eyes; the antennæ eight-segmented, with the last two segments (the style) shorter than the sixth; the maxillary palpi three-segmented, the prothorax very slightly, if at all, shorter than the head, with two long bristles at each posterior angle; the fore tibiæ unarmed; the bristles on the veins of the forewings not equidistant, and the last abdominal segment of the female conical and without a pair of short, stout bristles on the dorsal surface.

Until recently this species was placed in the genus Euthrips Targioni-Tozzetti, which most American authors had used in the sense of Physothrips and Odontothrips, Tæniothrips and Frankliniella. Hood[1] has recently shown that the name Euthrips Targioni-Tozzetti (1881) was first used in a subgeneric sense as a substitute for the name Thrips, which had been used for a subgenus of Thrips Linné (1758), and that it is consequently a synonym of that genus. The pear thrips he places in the genus Tæniothrips Amyot and Serville, the orange thrips in Scirtothrips Shull, and, partly following Karny,[2] the various other species formerly assigned to Euthrips in the genera Physothrips, Odontothrips, and Frankliniella.

## ANATOMY.[3]

### OVIPOSITOR.

The ovipositor is attached to the ventral side of the eighth and ninth abdominal segments and is composed of four distinct plates, the under pair attached to the eighth segment and the upper or posterior pair to the ninth abdominal segment. The ovipositor in

[1] Hood, J. Douglas. On the proper generic names for certain Thysanoptera of economic importance. *In* Proc. Ent. Soc. Wash., v. 14, no. 1, p. 34–44, 1914.

[2] Karny, H. Revision der von Serville aufgestellten Thysanoptera Genera. *In* Zoologische Annalen, Bd. 4, Heft 4, p. 322–344, 1912.

[3] For a description of the mouthparts see discussion under "Manner of feeding and type of mouthparts," p. 11–13.

the pear thrips is curved downward. The passageway between the plates is grooved so that the eggs can pass through readily. The upper edge (of the upper plates) is fitted with sharp sawlike teeth, while the lower plates have similar teeth for most of the way but also bear a number of broad cutting teeth. The end of the ovipositor is sharp and pointed. When this is inserted into the plant tissues, the slit or opening is enlarged by the action of the hard serrate edges of the ovipositor as it is worked up and down by the rather powerful muscles of the abdomen. The ovipositor when not in use is protected in a sheath along the ventral side of the last two segments of the abdomen.

#### WINGS.

The wings are long and slender, membranous, with a fringe of fine hair upon both the anterior and posterior margins, and are never folded. Both pairs of wings are quite similar and when at rest are laid back flat upon the abdomen, the pairs lying parallel in the Terebrantia. The wings of the family Thripidæ, to which the pear thrips belongs, are slender, and taper from the base to the tip, which is pointed; they bear a general resemblance to sabers. The veins in the family Thripidæ are not so prominent as in the family Æolothripidæ, and only one or two longitudinal veins are present, the cross-veins being very obscure.

#### FEET.

The legs and feet of thrips form one of the chief characteristics which separate this order from the various other orders of insects. They are composed of the usual parts of an insect leg, namely, coxa, trochanter, femur, tibia, and tarsus. There is nothing unusual in the formation of the first four parts, the femur and tibia usually being quite long and somewhat cylindrical. The tarsus is the most peculiar structure on the leg, and may be either simple or of two segments, and usually ends in one or two claws. In the family Thripidæ, they belong to the former type. The remarkable bladderlike structure, which for many years gave the name Physopoda to this order, is protrusile from the end of the last tarsal segment. It is present in both adults and larvæ. The end of the tarsus is cup-shaped, and into this cup the delicate membranous bladder is attached. When the foot is at rest the bladder is invisible and is withdrawn into the end segment. The bladder is protruded and brought into action when the adult is resting on some surface or walking around. The mechanism of the bladder has been partially worked out by Jordon and Uzel, but as it is somewhat intricate it will not be described here. If a swollen bladder is pricked or ruptured, the blood pours out and the bladder collapses quickly. The

blood is probably what causes the protrusion of the bladder. Various agencies have been used in experiments to hinder the thrips in walking about on the surfaces of the plants they are attacking, with the view that if in some way the mechanism of the bladder was affected, either by causticity or by absorption, the bladder would not be able to perform its function, and the insects would fall from any surfaces that were so treated. This has not been successful from the writers' experience, as they have observed on numerous instances thrips crawling around on sticky surfaces, even on tanglefoot, which was to all appearances and to the touch very sticky. This bladderlike formation is probably so delicate that surfaces which appear smooth or sticky or caustic to the naked eye and human touch are rough and uneven to the thrips and are neither adhesive nor caustic. The writers have never seen thrips stuck to any surface by the ends of their tarsi, but only by their bodies, legs, or wings. It is apparent that they are able to walk on practically every kind of surface, especially after this treated surface has been exposed to the atmosphere for a few hours.

## LIFE HISTORY AND HABITS.

### ADULTS IN SPRING.

#### EMERGENCE FROM GROUND.

The first form of the pear thrips to be seen by the orchardists during the growing season is the adult (Pl. I, fig. 1), which emerges from the ground during the last winter months and the early spring. The period in which they first appear upon the trees in Santa Clara, Contra Costa, Solano, and Sacramento Counties is variable. Certain sections in each territory are earlier than others and some orchards are in advance of others in regard to blossoming conditions.

In the Santa Clara Valley during the year 1909 the first adult thrips were collected February 15. (See Table IV.) By February 18 they were quite numerous in one of the orchards under observation and were common in all orchards by February 25. Maximum emergence began about February 19 and lasted until March 18. They continued to emerge until the first three days in April. In Contra Costa County first thrips were out at the laboratory February 12 and in the field February 16, emerging in numbers by February 20. Maximum emergence was over by March 15 and all were out by March 27. During the season of 1910 the first thrips taken in the field in Santa Clara County were observed on February 7, while the first in emergence cages appeared on February 9. They were common in the field from February 15 on. Thrips appeared in maximum numbers from the cages (see fig. 5) beginning February 22 and ending March 10, with the last stragglers coming out as late as March 20. The emergence season for 1911 at first gave promise

of being very early, as the first thrips were found in the field on January 29 and in the emergence cages February 1; but the heavy rains following in February and March caused it to be very backward, so that thrips were not common in the field until March 14, which was about the time of the true maximum emergence.

In Contra Costa County during the season of 1909 the maximum number of thrips emerged in cages, which were put in the ground in the yard at the laboratory, from February 23 to March 4. (See

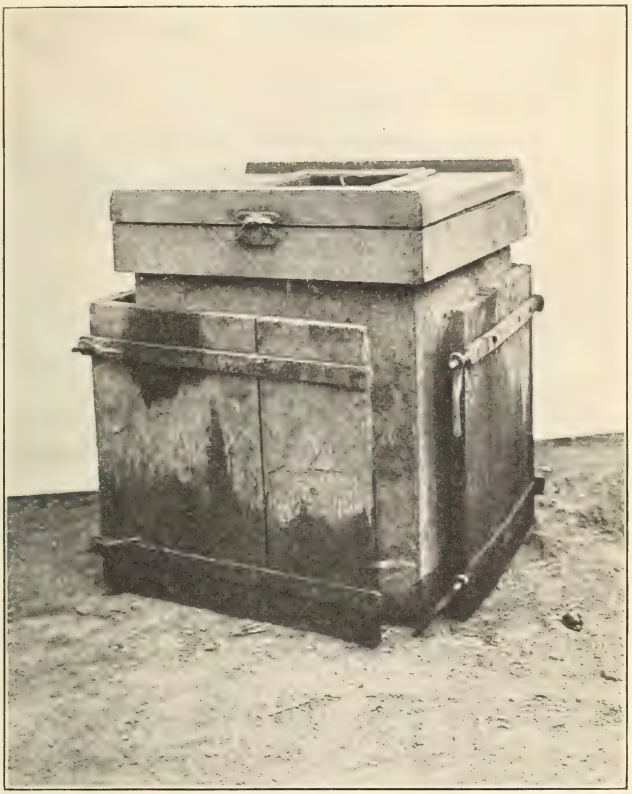


FIG. 5.—Type of soil cage used for soil samples in obtaining emergence records of the pear thrips at San Jose, Cal. (Original.)

Table VI and fig. 7.) In cages placed under trees (see fig. 6) in the field the thrips emerged in maximum numbers from February 26 to March 12 (see Table V and fig. 8). During the spring of 1910 the first thrips found to emerge in the cages at the laboratory were out on February 18 (see Table VI and fig. 9) and in the field cages on February 21, reaching a greater daily emergence by March 1, and continuing to emerge in considerable numbers until March 15, the maximum emergence being March 7 (see Table V and fig. 10). By comparing figures 7 and 8, which show the emergence records for

1909, with figures 9 and 10, showing the record for 1910, it will be seen that the time of emergence in any considerable numbers was much shorter in 1910 than was the case in 1909. No actual daily emergence records were kept in 1911, but no thrips were found in the field until February 18 and then only very few in one early almond orchard. On February 24 a few scattering specimens were found in two pear orchards. Not until March 12 were they appearing in any noticeable numbers, but the emergence was very rapid after this, reaching the maximum between March 15 and 20. The emergence of adults was mostly over by March 30.

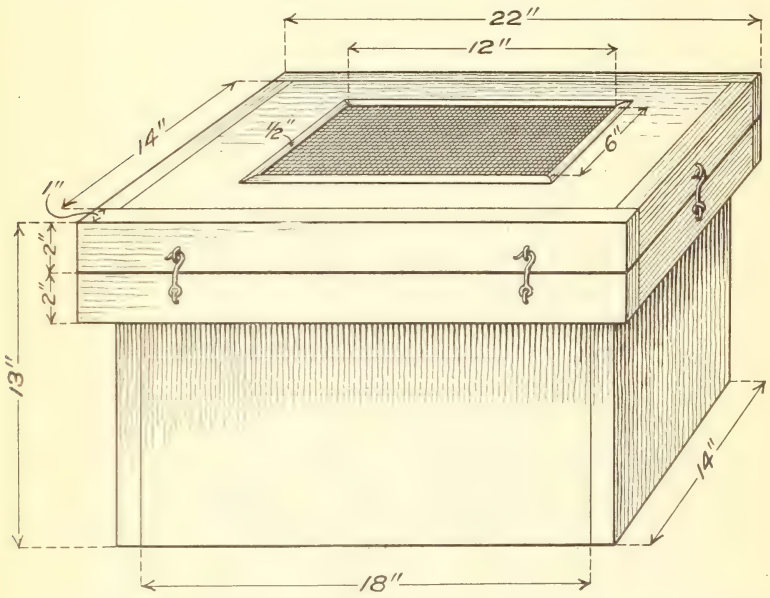



FIG. 6.—Type of wooden cage used for field emergence records of the pear thrips in orchards at Walnut Creek, Suisun, and Courtland, Cal., 1909–10. (Original.)

Emergence records and field observations in the Suisun Valley of Solano County (see Table VII and fig. 11) show that for the season of 1910 thrips came out of the ground in numbers on about the same dates as for Contra Costa County. They were out in numbers in the Courtland district of Sacramento County from two to four days earlier. Further observations in 1911 showed the emergence in these two sections to be about the same time as for Contra Costa County.

Records of the emergence for the years 1909, 1910, and 1911 are summarized in Table IV. From this table it will be seen that in Santa Clara County in 1909 most thrips appeared on March 3 while in 1910 March 4 yielded the highest number, with March 3 and 2

following close behind. The increase in emergence during the season 1909 (fig. 12) and the tapering off in the same year was more gradual

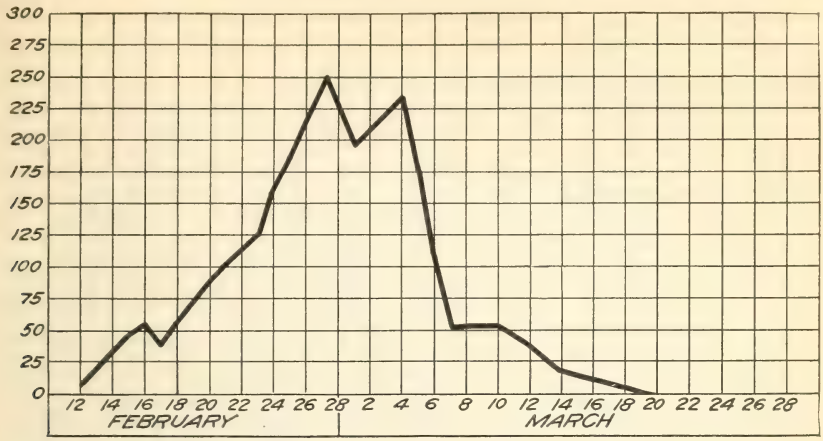



FIG. 7.—Curve illustrating emergence of adult pear thrips at laboratory, Walnut Creek, Cal., 1909. (Original.)

than during the season 1910 (fig. 13). This difference was most probably influenced during the latter season by the temperature.

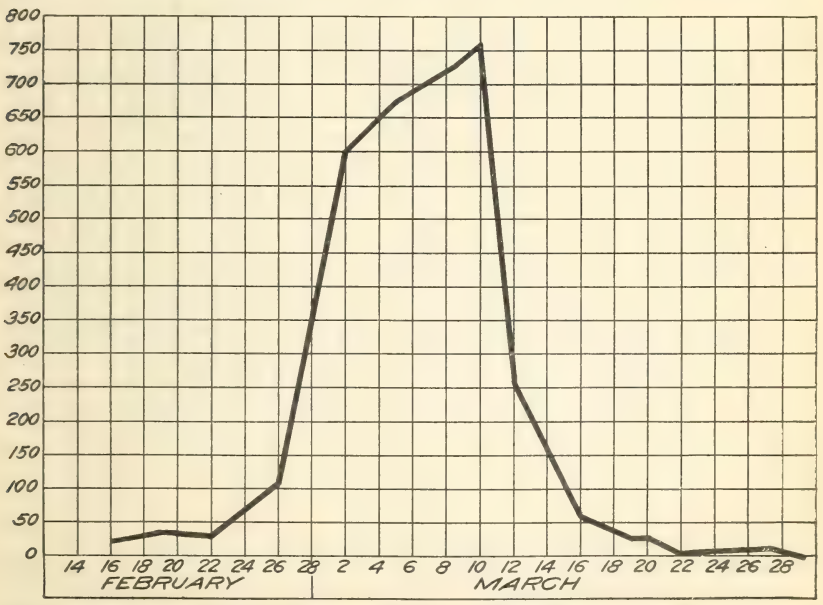



FIG. 8.—Curve showing emergence of pear thrips in cages under trees in field at Walnut Creek, Cal., 1909. (Original.)

### RELATION OF EMERGENCE TO TEMPERATURE AND RAINFALL.

The average mean temperature for February and March, 1911, or the two months when practically all of the thrips emerged, was

50.7° F., or about the same as in 1909, and the emergence probably would have been very similar to the emergence for that year but for the abnormal precipitation in February and March, especially in the latter month.

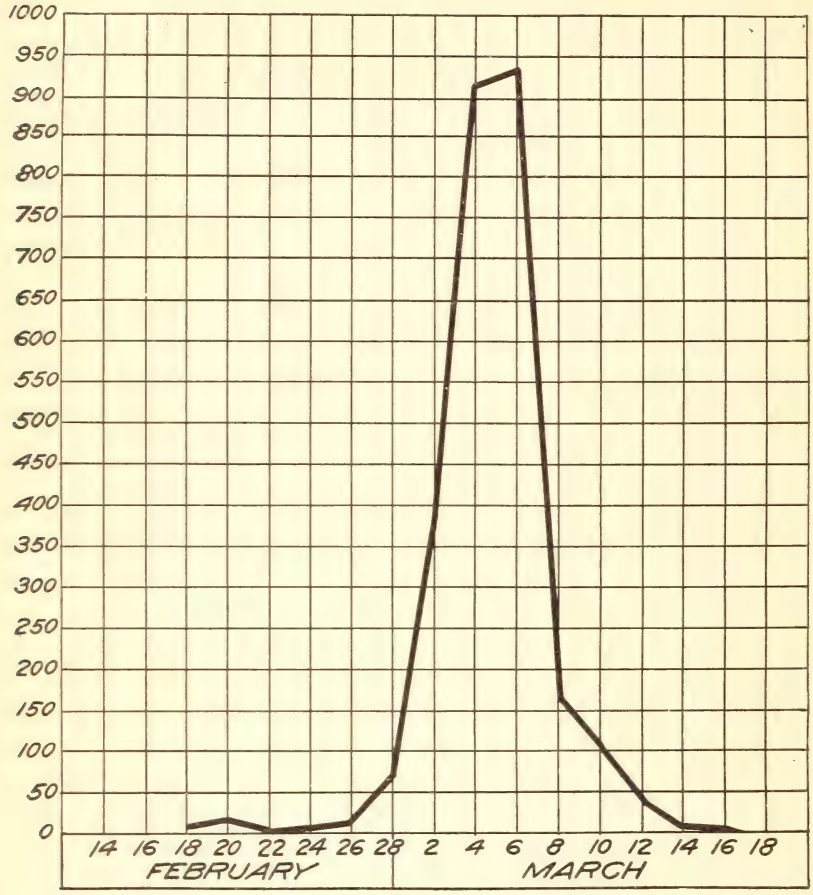



FIG. 9.—Curve showing emergence of adult thrips at laboratory, Walnut Creek, Cal., 1909. (Original.)

TABLE II.—*Mean temperatures for the months of February and March, 1909, 1910, and 1911.*

| | °F. |
|---|---|
| Mean maximum temperature for month of February, 1909 | 59.2 |
| Mean minimum temperature for month of February, 1909 | 42.2 |
| Average mean temperature for month of February, 1909 | 51.0 |
| Mean maximum temperature for month of March, 1909 | 60.0 |
| Mean minimum temperature for month of March, 1909 | 40.0 |
| Average mean temperature for month of March, 1909 | 50.0 |
| Mean maximum temperature for month of February, 1910 | 58.8 |
| Mean minimum temperature for month of February, 1910 | 38.5 |

| | ° F. |
|---|---|
| Average mean temperature for month of February, 1910 | 49.0 |
| Mean maximum temperature for month of March, 1910 | 66.2 |
| Mean minimum temperature for month of March, 1910 | 44.5 |
| Average mean temperature for month of March, 1910 | 55.0 |
| Mean maximum temperature for month of February, 1911 | 56.5 |
| Mean minimum temperature for month of February, 1911 | 37.3 |
| Average mean temperature for month of February, 1911 | 46.9 |
| Mean maximum temperature for month of March, 1911 | 63.3 |
| Mean minimum temperature for month of March, 1911 | 46.0 |
| Average mean temperature for month of March, 1911 | 54.6 |

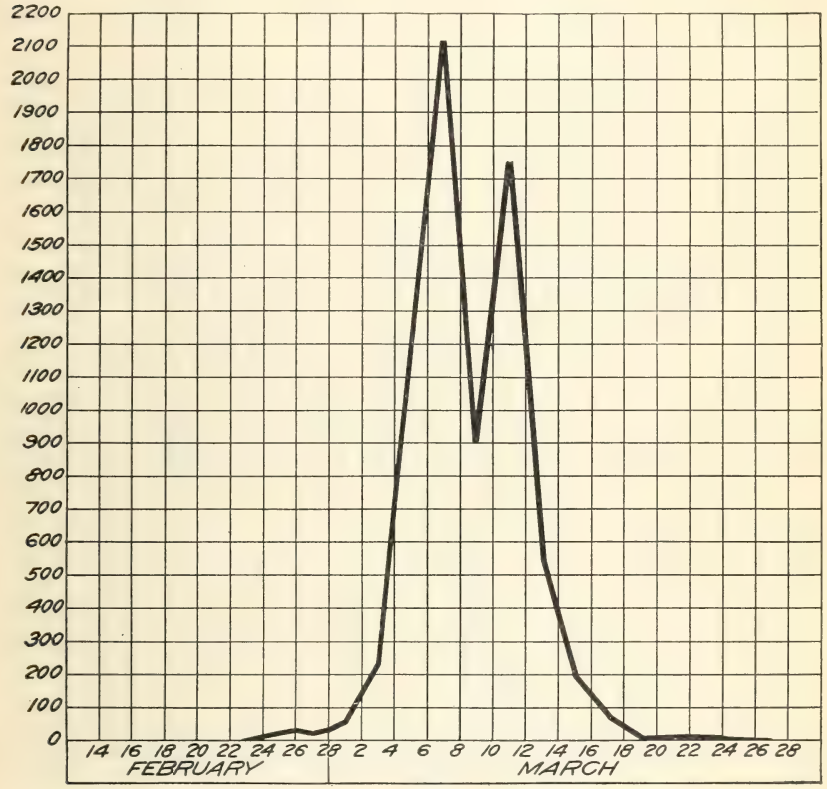



FIG. 10.—Curve showing emergence of adult pear thrips in cages under trees in field, at Walnut Creek, Cal., 1910. (Original.)

It will be seen from the temperature records (Table II) that while February, 1909, had 2 degrees higher average mean temperature than February of 1910, March of 1909 had 5 degrees less average mean temperature than March of 1910, making the average mean temperature for the months in which most of the adults emerged 50.5° F. in the year 1909 and 52° F. in the year 1910. Another factor which held back the emergence greatly the former year was the

greater rainfall, the month of February, 1909, having 4.87 inches precipitation while February of 1910 had only 0.83 of an inch.

A comparison of the amount of precipitation for the three years 1909, 1910, and 1911 (see Table III) shows a large amount for 1909,

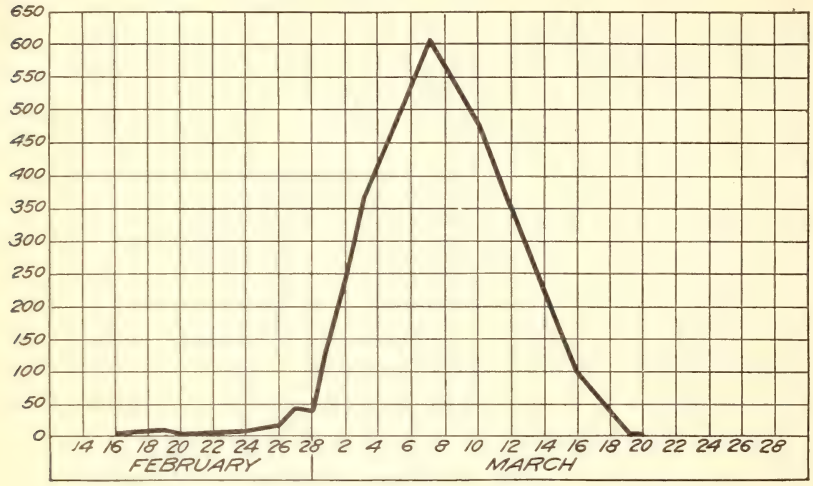



FIG. 11.—Curve showing emergence of pear thrips at Suisun, Cal., 1910. (Original.)

which with the low average mean temperature for the two emergence months caused the emergence to be drawn out. The season 1911 was very abnormal in the large amount of precipitation, especially

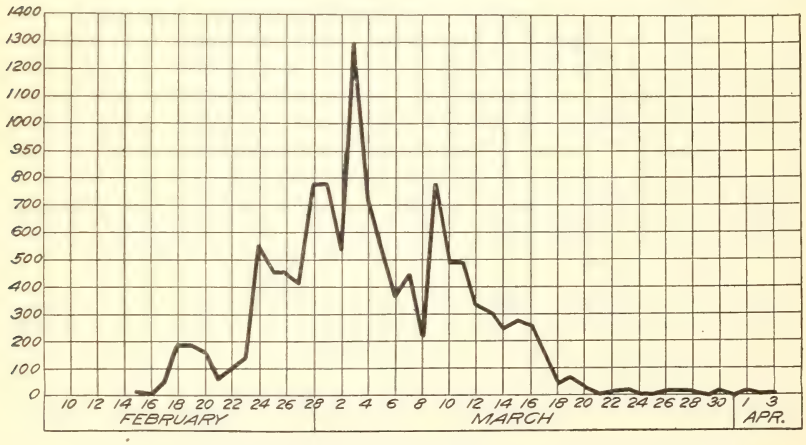



FIG. 12.—Curve showing emergence of pear thrips at San Jose, Cal., 1909. (Original.)

during the latter part of February and early March, causing a late blossoming season, and holding the thrips back to such an extent that comparatively little injury was caused by the adults.

TABLE III.—*Total precipitation for the years 1909, 1910, and 1911 at San Jose, Cal., laboratory.*

| Month. | Precipitation in inches. | | |
|---|---|---|---|
| | 1909 | 1910 | 1911 |
| February | 4.87 | 0.83 | 2.03 |
| March | 2.77 | 2.84 | 6.26 |

One curious fact about the emergence for 1911 was the double maximum, one the latter part of February, from the 18th to the 26th, and another from the 8th to the 15th of March. (See Table IV and

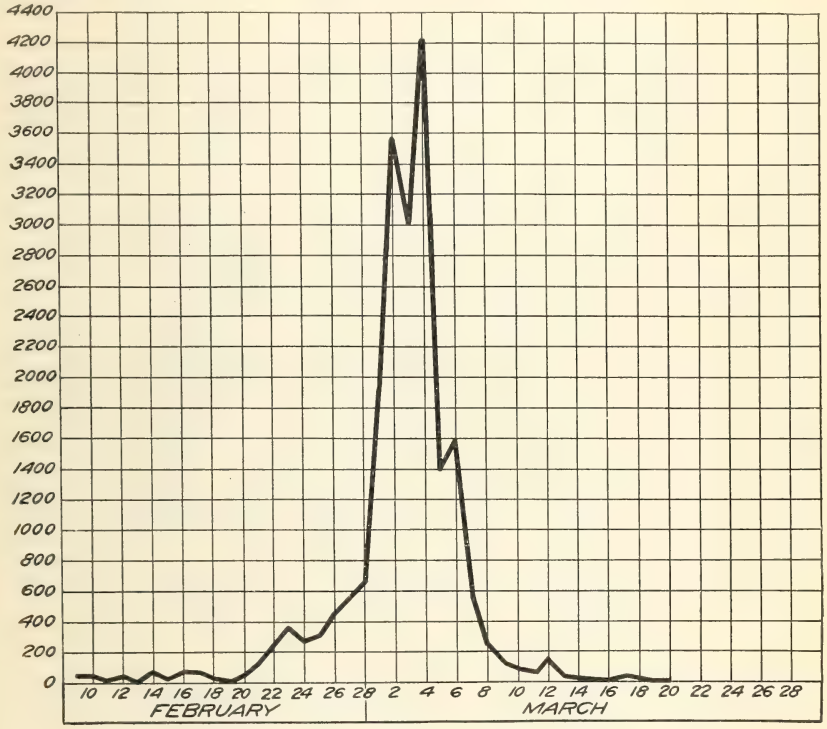



FIG. 13.—Curve showing emergence of pear thrips at San Jose, Cal., 1910. (Original.)

fig. 14.) From February 26 to March 11, inclusive, it rained every day from 0.02 of an inch to as much as 2.45 inches. Probably a number of the thrips which emerged in February were killed by the heavy rains in early March, or at least were not permitted to cause much injury. The pear thrips emerges from the ground during rainy weather, but not in such great numbers as during warm, sunshiny days, which was the case during the latter part of February and the early part of March of the year 1910. Whether the soil is clean or covered with weeds and grass at this time of year influences the time

of emergence by some two or three days. This was particularly noticeable in pear orchards used in cultivation experiments in Contra Costa and Solano Counties. In the plowed portions which were free from weeds, the surface dried out and warmed up more rapidly and thrips came out in numbers and into the trees three days earlier than on the unplowed part of the orchard, which was covered with a rank growth of vegetation. The shading of the soil by the vegetation seems to result in holding the thrips within the ground several days later, or else they spend some time on this succulent growth before going into the trees.

The following tables give the emergence records for the years 1909, 1910, 1911, and 1912 for Santa Clara County (San Jose, Table IV);

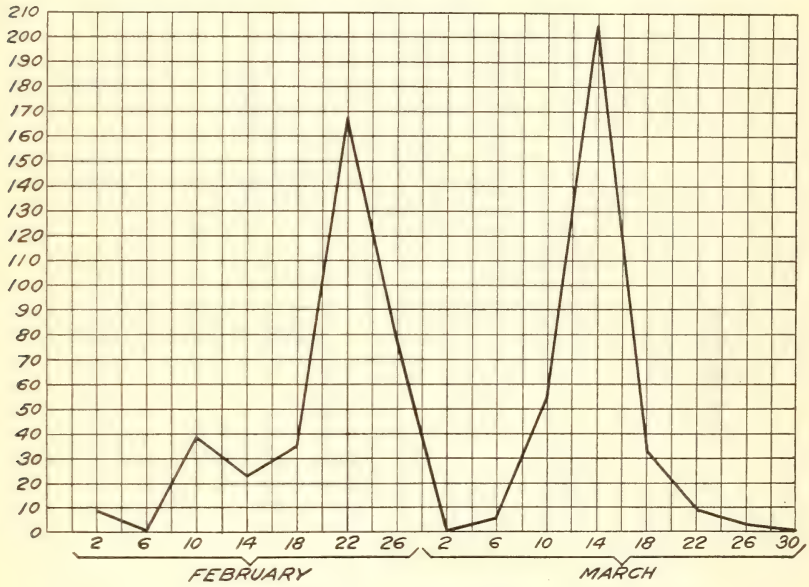



FIG. 14.—Curve showing emergence of pear thrips at San Jose, Cal., 1911. (Original.)

for 1909 and 1910 in Contra Costa County (Walnut Creek, Tables V and VI), and for 1910 in Solano County (Suisun, Table VII). These tables show the total number of thrips emerging on the given dates from soil in the cages. For the San Jose records, all the cages containing soil samples from infested prune orchards were placed in the ground at the laboratory. For the records in Contra Costa and Solano Counties, part of the cages were brought to the laboratory and buried in the ground and part were left in the ground under the trees in infested orchards. (See fig. 6 for type of cage used for the field emergence records in the northern counties.) It was not possible to take the emergence every day, but, so far as possible, counts were made at regular intervals.

TABLE IV.—*Total emergence of pear thrips from all the cages kept at the laboratory at San Jose, Santa Clara County, Cal., during 1909, 1910, 1911, and 1912.*

| Date | Number of thrips emerging in 1909 from 18 cages. | Number of thrips emerging in 1910 from 18 cages. | Number of thrips emerging in 1911 from 4 cages. | Number of thrips emerging in 1912 from 4 cages. | Date. | Number of thrips emerging in 1909 from 18 cages. | Number of thrips emerging in 1910 from 18 cages. | Number of thrips emerging in 1911 from 4 cages. | Number of thrips emerging in 1912 from 4 cages. |
|---|---|---|---|---|---|---|---|---|---|
| Feb. 1 | 0 | 0 | 2 | 1 | Mar. 9 | 776 | 144 | 1 | 366 |
| 2 | 0 | 0 | 7 | 1 | 10 | 497 | 100 | 32 | 442 |
| 3 | 0 | 0 | 0 | 0 | 11 | 498 | 73 | 54 | 81 |
| 4 | 0 | 0 | 0 | 0 | 12 | 338 | 179 | 71 | 83 |
| 5 | 0 | 0 | 0 | 1 | 13 | 313 | 45 | 56 | 161 |
| 6 | 0 | 0 | 1 | 5 | 14 | 248 | 20 | 22 | 313 |
| 7 | 0 | 0 | 28 | 3 | 15 | 279 | 7 | 17 | 433 |
| 8 | 0 | 0 | 5 | 6 | 16 | 259 | 4 | 9 | 239 |
| 9 | 0 | 25 | 1 | 9 | 17 | 152 | 20 | 2 | 158 |
| 10 | 0 | 18 | 4 | 9 | 18 | 42 | 7 | 4 | 596 |
| 11 | 0 | 16 | 1 | 9 | 19 | 61 | 2 | 0 | 209 |
| 12 | 0 | 16 | 22 | 21 | 20 | 28 | 2 | 0 | 144 |
| 13 | 0 | 4 | 0 | 15 | 21 | 2 | 0 | 3 | 106 |
| 14 | 0 | 88 | 0 | 33 | 22 | 6 | 0 | 6 | 114 |
| 15 | 18 | 22 | 11 | 37 | 23 | 13 | 0 | 1 | 103 |
| 16 | 0 | 27 | 5 | 65 | 24 | 3 | 0 | 1 | 68 |
| 17 | 52 | 34 | 2 | 104 | 25 | 2 | 0 | 0 | 52 |
| 18 | 192 | 33 | 17 | 242 | 26 | 3 | 0 | 1 | 39 |
| 19 | 192 | 14 | 62 | 490 | 27 | 7 | 0 | 1 | 38 |
| 20 | 169 | 23 | 41 | 384 | 28 | 7 | 0 | 0 | 61 |
| 21 | 75 | 62 | 32 | 325 | 29 | 0 | 0 | 0 | 17 |
| 22 | 119 | 129 | 33 | 440 | 30 | 2 | 0 | 0 | 14 |
| 23 | 135 | 375 | 25 | 422 | 31 | 0 | 0 | 0 | 14 |
| 24 | 552 | 272 | 26 | 515 | Apr. 1 | 3 | 0 | 0 | 28 |
| 25 | 459 | 297 | 18 | 800 | 2 | 0 | 0 | 0 | 19 |
| 26 | 444 | 455 | 8 | 504 | 3 | 1 | 0 | 0 | 9 |
| 27 | 414 | 574 | 0 | 762 | 4 | 0 | 0 | 0 | 7 |
| 28 | 781 | 657 | 0 | 1,694 | 5 | 0 | 0 | 0 | 4 |
| 29 | ..... | ..... | ..... | 1,169 | 6 | 0 | 0 | 0 | 4 |
| Mar. 1 | 781 | 1,975 | 0 | 1,721 | 7 | 0 | 0 | 0 | 26 |
| 2 | 535 | 3,592 | 0 | 276 | 8 | 0 | 0 | 0 | 5 |
| 3 | 1,299 | 3,011 | 2 | 284 | 9 | 0 | 0 | 0 | 3 |
| 4 | 714 | 4,217 | 4 | 399 | 10 | 0 | 0 | 0 | 1 |
| 5 | 508 | 1,402 | 0 | 400 | 11 | 0 | 0 | 0 | 1 |
| 6 | 362 | 1,595 | 0 | 585 | 12 | 0 | 0 | 0 | 0 |
| 7 | 438 | 539 | 1 | 1,227 | | | | | |
| 8 | 219 | 275 | 21 | 1,052 | Total.. | 11,998 | 20,350 | 660 | 17,968 |

TABLE V.—*Emergence of pear thrips from cages placed in ground under trees in pear and prune orchards, Walnut Creek, Contra Costa County, Cal.*

| Date. | Number of thrips emerging. | Date. | Number of thrips emerging. |
|---|---|---|---|
| 1909. | | 1910. | |
| Feb. 13 | 0 | Feb. 21 | 1 |
| 16 | 20 | 23 | 4 |
| 19 | 37 | 25 | 23 |
| 22 | 30 | 27 | 36 |
| 26 | 110 | Mar. 1 | 56 |
| Mar. 2 | 615 | 3 | 237 |
| 5 | 679 | 5 | 1,170 |
| 10 | 752 | 7 | 2,110 |
| 12 | 273 | 9 | 892 |
| 16 | 65 | 11 | 1,773 |
| 20 | 33 | 13 | 557 |
| 22 | 4 | 15 | 198 |
| 27 | 11 | 17 | 71 |
| | | 19 | 3 |
| | | 21 | 6 |
| | | 27 | 5 |

TABLE VI.—*Emergence of pear thrips from soil samples taken from orchards in December and January and kept in cages at laboratory, Walnut Creek, Contra Costa County, Cal.*

| Date. | Number of thrips emerging. | Date. | Number of thrips emerging. |
|---|---|---|---|
| 1909. | | 1910. | |
| Feb. 12 | 3 | Feb. 18 | 11 |
| 15 | 42 | 20 | 16 |
| 16 | 56 | 22 | 0 |
| 17 | 38 | 24 | 12 |
| 18 | 56 | 26 | 30 |
| 20 | 89 | 28 | 75 |
| 23 | 125 | Mar. 2 | 377 |
| 25 | 185 | 4 | 918 |
| 27 | 246 | 6 | 937 |
| Mar. 1 | 196 | 8 | 165 |
| 4 | 237 | 10 | 114 |
| 7 | 51 | 12 | 47 |
| 10 | 52 | 14 | 0 |
| 14 | 13 | 16 | 4 |
| 19 | 0 | | |
| 22 | 0 | | |

TABLE VII.—*Emergence records of pear thrips for Suisun, Solano County, Cal., 1910.*

| Emergence of thrips from cages placed in ground under trees in orchards, Suisun, Cal. | | Emergence of thrips from soil samples taken from orchards in December and January and kept in cages at laboratory, Suisun, Cal. | |
|---|---|---|---|
| Date. | Number of thrips emerging. | Date. | Number of thrips emerging. |
| Feb. 17 | 3 | Feb. 16 | 1 |
| 19 | 0 | 17 | 3 |
| 21 | 0 | 18 | 2 |
| 23 | 0 | 19 | 6 |
| 25 | 1 | 20 | 1 |
| 27 | 20 | 21 | 1 |
| Mar. 1 | 47 | 22 | 4 |
| 3 | 121 | 23 | 2 |
| 10 | 484 | 24 | 5 |
| 16 | 1 | 25 | 11 |
| | | 26 | 11 |
| | | 27 | 14 |
| | | 28 | 41 |
| | | Mar. 1 | 105 |
| | | 2 | 247 |
| | | 3 | 243 |
| | | 7 | 612 |
| | | 12 | 357 |
| | | 16 | 82 |
| | | 19 | 8 |

The latest dates on which adult thrips were collected in the field were about the same for the years 1909 and 1910, the last ones being found from April 15 to April 25. In 1911 living adults were found as late as the middle of May. They were very scarce, however, after May. The number of living adults as a rule decreases rapidly after April 1.

The time adults will feed before they begin ovipositing varies. Those individuals which emerge early and which do not have a suit-

able place for ovipositing will feed from 15 to 20 days before placing any eggs, while individuals which emerge at a later date, as, for instance, from March 5 to 20, do not as a rule feed more than one or two days before depositing eggs. Individuals which were taken from emergence cages and placed in mica chimneys were observed ovipositing the day following their emergence. It is possible that in the field thrips begin depositing eggs more quickly on certain varieties of fruits than on others. This would be governed very largely by the presence or absence of available tissue suitable for oviposition. For this reason on the early blooming varieties of cherries thrips probably feed for a shorter time before oviposition commences than is the case with other fruits.

#### PERIOD OF EGG LAYING FOR INDIVIDUALS.

The egg-laying period for individuals does not usually last for more than three weeks. Individual thrips confined in mica chimneys on March 5, 1910, did not deposit any eggs after the latter part of March. The full period of egg laying for the entire brood throughout all the infested areas extends from about February 20 until near April 10, or a period of six to seven weeks.

#### LENGTH OF LIFE OF ADULTS.

Adult thrips confined in vials without food lived on an average three days, while those confined in vials with food lived about two weeks. Adult thrips confined on the trees within mica chimneys lived from three weeks to one month. The length of life of individuals in the field has not been observed accurately, but probably ranges in duration from three weeks to one month and a half.

#### RELATION OF EMERGENCE TO BLOSSOMING OF TREES.

The emergence period extends from early February to early April and is closely associated with the blossoming periods for the different varieties of fruits. Budding and blossoming of the different fruits is as follows: Almond buds begin to swell during the latter part of January and early February, and this variety of fruit is in full bloom between February 8 and 24. Apricots show first blossoms from February 12 to 23, and most varieties are in full bloom by from March 3 to 10. Peaches show first blossoms about February 23 and many varieties are in full bloom from March 8 to March 17. Black Tartarian cherries reach full bloom by March 15 to 20, while the Royal Anne variety has not at that time opened its buds. French prune buds are beginning to swell between March 8 and 11 and first blossoms appear by March 20. They are usually in full bloom between

March 26 and April 8. The Sugar and Imperial varieties precede the French by about one week. Bartlett pear buds begin to swell the last of February or the first of March, the first clusters usually spreading from March 10 to 15 and are in full bloom for quite an indefinite period between March 20 and April 10. Pears, prunes, and cherries, which are spreading their bud clusters just after the maximum numbers of thrips are coming from the ground, are the fruits most seriously injured by the pear thrips.

### MIGRATORY HABITS.

Evidences of the migratory habits of the pear thrips have been noticed at times during the last three or four years. However, no definite observations concerning their migration had been made until the year 1910. Hitherto it had been noted that in some orchards the adults were very numerous early in the season and doing extensive damage. Later observations at an interval of four or five days showed very few adults present, and the entire orchard had the characteristic browned and burnt appearance. It was quite evident that after destroying all the fruit buds the thrips had migrated to other orchards in search of food.

It was possible to obtain more definite knowledge regarding migration in the year 1910 than had heretofore been known, for the reason that the thrips were unusually numerous throughout all the infested areas that year and weather conditions were such that practically the entire brood emerged from the ground in a few days. Also, following their emergence in great numbers, the weather was sufficiently warm that the destruction of the fruit buds in the various orchards was accomplished in much shorter time than is usually the case. Observations so far indicate that thrips migrate in swarms only on bright, warm days. Numerous instances of supposed migration were mentioned to the writers at various times during the season, the reports stating that the pear thrips were flying in swarms, but most of the cases reported lacked authentic evidence to bear them out, such as the saving of specimens. However, in the afternoon of March 28, 1910, the junior author drove out from San Jose toward Saratoga and had great difficulty in keeping both hands on the reins on account of the great numbers of thrips which, flying through the air, filled his eyes and covered his clothes. The prevailing direction of the wind on this day was not observed; no distinct migration or swarm was noted, however, although individuals were numerous flying across the road and could be readily seen when the observer looked toward the sun. They were more numerous on roads running north and south, and extended over a territory of 4 or 5 miles; they were the most numer-

ous at the west end of Hamilton Avenue and along the San Tomas and Santa Clara and Los Gatos Roads.

On March 30, 1910, still more definite information was gained, and this is probably the most unique record of thrips migration which has yet been taken. The day was bright and rather warm and ended with the evening warm and a gentle breeze blowing from the south. Mr. E. L. Fellows, who was in Santa Clara on this day, started home about 5 o'clock in the afternoon. About 5.15 p. m., out on the Saratoga Road, he noticed a number of small, black insects which covered his face and hands, his hat and clothes, and got into his eyes. When he was one-fourth of a mile north of Meridian Corners he met the thickest part of the swarm, which appeared literally like a black, glistening, seething mass moving up and down like heat waves. From this place the insects became less numerous as he went toward home, which he reached about 6 p. m. He thought the swarm to be about 8 miles long and 4 miles wide, from 4 to 15 feet high, moving at the rate of about 10 miles per hour northward toward San Francisco Bay. As he was not sure concerning the identity of this insect, he gathered several hundred specimens in a paper bag and submitted them to the junior author for identification. They were found to be the pear thrips, *Tæniothrips pyri*. This same swarm was noticed by the junior author and by several fruit growers, but they did not have the opportunity to view the whole swarm as did Mr. Fellows.

Continued observations during the season of 1910 showed that the usual time for migration was from 3 to 6 p. m. on bright, warm days during the latter part of the period of maximum oviposition, which was also about the time many orchards have been so badly injured that the trees will not bloom.

This migratory habit is undoubtedly influenced chiefly by a desire for a new supply of food, better places for deposition of eggs, and suitable weather conditions, especially the temperature. The direction in which thrips will migrate depends upon the direction the wind is blowing, and the distance at which suitable feeding places are found.

No distinct migration of the whole brood has ever been observed, such as is the case with some species of Orthoptera. The migration from certain badly infested orchard localities has been influenced, without doubt, by the early destruction of the fruit buds in these orchards. Many instances are known where thrips are numerous and their injury severe in an orchard one year and not very numerous the succeeding year, but they are usually highly injurious again the third year. This phenomenon is more noticeable in pear than in prune orchards, due probably to the fact that a pear

orchard in which all fruit buds have been destroyed is poor feeding ground for both adults and larvæ and reproduction is at the minimum under such conditions. This reappearance in damaging numbers the third year makes it evident that the orchardists should not allow their orchards to go untreated. It should be noted that the years 1907 and 1910 were the only seasons in which the pear thrips migrated to any great extent. No migration was known in the season of 1911, although it was watched for.

### MANNER OF REACHING TREE TOPS FROM GROUND.

Most of the adults when emerging probably crawl around for a while on the ground until their wings get sufficiently dry and then fly up into the tree. Some, however, must undoubtedly crawl up the trunk, as a few have been caught by tanglefoot bands. This, however, can not be used as a method of control, since very few go up this way; moreover, the thrips would not be caught unless the bands were renewed every day or so, because the bands do not remain sufficiently sticky after a short exposure to the atmosphere.

### REPRODUCTION.

According to Bagnall [1] an example of the male pear thrips was found by him among some specimens of this species taken from plum blossoms at Evesham, England, and submitted to him by Mr. Collinge, director of the Cooper Research Laboratory at Berkhamstead. His only description is that "It is much smaller than the female and the wings considerably overreach the tip of the abdomen." This is the first report of the existence of the male of this species, and in California very extensive observations by the writers and other workers have failed to show a single male, and the only type of reproduction known is by parthenogenesis. In all of the life-history experiments to secure data upon the length of the egg stage individual females were taken directly from the emergence cages and isolated. It is highly probable that practically all of the eggs which are deposited hatch, as no sterile eggs have ever been found.

### OVIPOSITION.

Moulton [2] states that he has observed the adult in ovipositing to make first a hole in the epidermis of the plant tissue with the mouth before depositing the egg. Repeated observations by the writers of a large series of adults during oviposition have failed to

[1] Bagnall, Richard S. A contribution to our knowledge of the British Thysanoptera (Terebrantia), with notes on injurious species. *In* Jour. Econ. Biol., v. 4, no. 2, p. 33–41, July 7, 1909. See p. 39.

[2] Moulton, Dudley. The Pear Thrips (*Euthrips pyri* Daniel). U. S. Dept. Agr., Bur. Ent., Bul. 68, pt. 1, rev., p. 7, Sept. 20, 1909.

show a single one going through this procedure. The usual method as shown by observations during the season of 1910 is as follows: The female starts the ovipositor into the tissue by working the abdomen up and down, gradually forcing the ovipositor its full length into the tissue. After this is done the thrips remains quiet for a short interval while the egg is passing out between the plates of the ovipositor. When finished, the female vibrates her antennae and jerks out the ovipositor. The prevailing posture during the whole period of oviposition is with the abdomen arched and the legs spread apart wider than when in walking. The average time required for the operation by a number of individuals observed during the season of 1910 ranged from three to five minutes. After depositing an egg the female usually resumes feeding for a short interval, but some individuals have been observed to deposit two and three eggs in succession without any feeding between times. The number of eggs that a female can deposit in a day is probably not over seven or eight, as the abdominal cavity is not large enough to hold more at one time.

## EGGS.

### PLACE OF DEPOSITION.

The eggs are always placed in the tenderest portions of the plant tissue, such as exposed blossoms, fruit stems, leaf stems, ribs of the leaves (preferably the midribs), and the leaf edges. Still others are placed in the young fruits. The pear thrips apparently prefers to oviposit upon cherries if a cherry tree is at hand, as the fruit and leaf stems, on account of their length and tenderness, offer excellent places for oviposition without making it necessary for the thrips to move over a large area. However, the small prunes and the stems, as also the stems and midribs of the young leaves of both prunes and pears, are well suited for oviposition by this species. The counts in Table VIII were taken upon leaf stems and fruit stems of French prunes and show the comparative percentage of eggs deposited in each; they also show the inability of the different spray mixtures to kill the eggs within the plant tissues, as these stems in question had been sprayed two days previously with a combination of tobacco extract and distillate emulsion.

TABLE VIII.—*Comparative percentage of eggs deposited in fruit stems and leaf stems of French prunes, San Jose, Cal., season of 1910.*

| No. of observation. | Number of eggs in leaf stems. | Number of eggs in fruit stems. | No. of observation. | Number of eggs in leaf stems. | Number of eggs in fruit stems. |
|---|---|---|---|---|---|
| 1 | 2 | 7 | 44 | 1 | 12 |
| 2 | 1 | 10 | 45 | 0 | 11 |
| 3 | 5 | 5 | 46 | 7 | 8 |
| 4 | 0 | 12 | 47 | 3 | 8 |
| 5 | 2 | 13 | 48 | 7 | 9 |
| 6 | 1 | 6 | 49 | 5 | 11 |
| 7 | 3 | 8 | 50 | 2 | 9 |
| 8 | 0 | 8 | 51 | 12 | 9 |
| 9 | 0 | 8 | 52 | 10 | 11 |
| 10 | 1 | 9 | 53 | 2 | 9 |
| 11 | 1 | 8 | 54 | 3 | 10 |
| 12 | 2 | 10 | 55 | 7 | 12 |
| 13 | 2 | 4 | 56 | 0 | 6 |
| 14 | 5 | 6 | 57 | 9 | 10 |
| 15 | 3 | 10 | 58 | 5 | 10 |
| 16 | 2 | 11 | 59 | 12 | 4 |
| 17 | 0 | 5 | 60 | 5 | 11 |
| 18 | 3 | 12 | 61 | 0 | 17 |
| 19 | 3 | 10 | 62 | 6 | 9 |
| 20 | 1 | 8 | 63 | 2 | 13 |
| 21 | 0 | 6 | 64 | 4 | 9 |
| 22 | 0 | 3 | 65 | 5 | 12 |
| 23 | 3 | 10 | 66 | 8 | 6 |
| 24 | 1 | 9 | 67 | 0 | 7 |
| 25 | 1 | 5 | 68 | 11 | 8 |
| 26 | 2 | 13 | 69 | 8 | 9 |
| 27 | 1 | 10 | 70 | 5 | 16 |
| 28 | 1 | 5 | 71 | 9 | 7 |
| 29 | 1 | 9 | 72 | 3 | 8 |
| 30 | 2 | 8 | 73 | 2 | 9 |
| 31 | 0 | 16 | 74 | 2 | 7 |
| 32 | 2 | 8 | 75 | 9 | 11 |
| 33 | 2 | 4 | 76 | 17 | 8 |
| 34 | 1 | 15 | 77 | 6 | 10 |
| 35 | 0 | 9 | 78 | 11 | 4 |
| 36 | 0 | 11 | 79 | 12 | 8 |
| 37 | 1 | 7 | 80 | 9 | 14 |
| 38 | 4 | 19 | 81 | 8 | 9 |
| 39 | 7 | 16 | 82 | 2 | 8 |
| 40 | 2 | 13 | 83 | 1 | 11 |
| 41 | 5 | 7 | 84 | 0 | 11 |
| 42 | 3 | 12 | | | |
| 43 | 3 | 9 | Total... | 299 | 786 |

It will be seen from this table that the average number of eggs placed within fruit stems of prunes is more than twice the number placed in the leaf stems. In pears a very large proportion of eggs is placed in ribs and veins of leaves and a comparatively smaller percentage in the fruit stems.

### FIRST EGGS.

The first eggs that were noticed in the vicinity of San Jose and in Contra Costa County were placed about March 10 for the season of 1909, while most eggs were being placed about March 15 to 25, and the last eggs in early April. The first eggs were deposited in 1910 in the field about March 9, while maximum oviposition was from March 18 until about April 2. The last eggs were observed to be placed in the field toward the middle of April. In the interior counties, especially Sacramento and Solano Counties, eggs were being deposited in large numbers by March 15, and continued to be deposited in numbers until the latter part of March, a few being found in early April.

LENGTH OF EGG STAGE.

Moulton[1] records the length of the egg stage to be approximately four days, but detailed observations during the season of 1910 at San Jose show it to be considerably longer. The length of the egg stage was first ascertained by inclosing twigs with paper bags before thrips emerged so as to get no outside infestation. Later, when thrips were ovipositing in the field, a considerable number of adults were placed in mica chimneys which had been specially constructed to fit over the twigs in such a manner as to give them as nearly natural conditions as possible, and to permit the eggs to remain in living plant tissue because they usually dried out when the twigs were removed from the tree. These chimneys were made by sewing pieces of strong white cloth in the shape of tubes about 5 or 6 inches long and gluing one end of a cloth tube thus made to each end of the mica chimney. When placed upon the tree, ends of the cloth were tied securely around the twig so that no insects could get in from the outside. The thrips kept for oviposition remained in the cages over night and were removed the next day. To make sure that none would remain in to continue ovipositing, new cages were placed on the twigs in each case. Table IX shows the length of the egg stage.

TABLE IX.—*Length of egg stage of the pear thrips, San Jose, Cal., 1910.*

| Cage No. | Date deposited. | Date hatched. | Number of eggs hatched. | Length of egg stage. | Average mean temperature. | Prevailing weather. |
|---|---|---|---|---|---|---|
| | | | | *Days.* | ° *F.* | |
| I | Mar. 10 | Mar. 16 | 25 | 6 | 56 | Cloudy. |
| | | 17 | 6 | 7 | 57 | Do. |
| | | 18 | 9 | 8 | 58 | Do. |
| | | 19 | 8 | 9 | 57 | Do. |
| | | 20 | 3 | 10 | 57 | Do. |
| | | 22 | 10 | 12 | 52 | Do. |
| | | 23 | 3 | 13 | 52 | Do. |
| | | 24 | 1 | 14 | 52 | Do. |
| II | Mar. 10 | Mar. 16 | 13 | 6 | 56 | Cloudy. |
| | | 17 | 27 | 7 | 57 | Do. |
| | | 18 | 30 | 8 | 58 | Do. |
| | | 19 | 35 | 9 | 57 | Do. |
| | | 20 | 8 | 10 | 57 | Do. |
| III | Mar. 10 | Mar. 16 | 27 | 6 | 56 | Cloudy. |
| | | 17 | 4 | 7 | 57 | Do. |
| | | 18 | 9 | 8 | 58 | Do. |
| | | 19 | 14 | 9 | 57 | Do. |
| | | 20 | 10 | 10 | 57 | Do. |
| | | 22 | 4 | 12 | 52 | Do. |
| | | 23 | 1 | 13 | 52 | Do. |
| | | 24 | 1 | 14 | 52 | Do. |
| IV | Apr. 7 | Apr. 14 | 3 | 7 | 55 | Clear. |
| V | Mar. 29 | Apr. 5 | 1 | 7 | 56 | Clear. |
| | | 8 | 1 | 10 | 56 | Do. |
| | | 10 | 1 | 12 | 56 | Do. |
| VI | Mar. 29 | Apr. 7 | 2 | 9 | 56 | Clear. |
| | | 9 | 4 | 11 | 56 | Do. |
| | | 10 | 1 | 12 | 56 | Do. |
| | | 12 | 1 | 14 | 55 | Do. |

[1] Op. cit., p. 8.

TABLE IX.—*Length of egg stage of the pear thrips, San Jose, Cal., 1910*—Continued.

| Cage No. | Date deposited. | Date hatched. | Number of eggs hatched. | Length of egg stage. | Average mean temperature. | Prevailing weather. |
|---|---|---|---|---|---|---|
| | | | | *Days.* | *° F.* | |
| VII | Mar. 29 | Apr. 3 | 1 | 5 | 56 | Clear. |
| | | 8 | 1 | 10 | 56 | Do. |
| VIII | Mar. 29 | Apr. 7 | 1 | 9 | 56 | Clear. |
| | | 8 | 7 | 10 | 56 | Do. |
| | | 9 | 3 | 11 | 56 | Do. |
| | | 10 | 4 | 12 | 56 | Do. |
| IX | Mar. 29 | Apr. 2 | 1 | 4 | 57 | Clear. |
| | | 6 | 1 | 8 | 56 | Do. |
| | | 7 | 1 | 9 | 56 | Do. |
| | | 8 | 4 | 10 | 56 | Do. |
| | | 10 | 4 | 12 | 56 | Do. |
| | | 14 | 1 | 16 | 55 | Do. |
| X | Apr. 6 | Apr. 12 | 1 | 6 | 54 | Cloudy. |
| XI | Apr. 6 | Apr. 13 | 1 | 7 | 54 | Cloudy. |
| XII | Apr. 6 | Apr. 13 | 2 | 7 | 54 | Cloudy. |

SUMMARY.

| Number eggs deposited. | Time required for incubation. | Number eggs deposited. | Time required for incubation. |
|---|---|---|---|
| | *Days.* | | *Days.* |
| 1 | 4 | 34 | 10 |
| 1 | 5 | 7 | 11 |
| 66 | 6 | 24 | 12 |
| 44 | 7 | 4 | 13 |
| 49 | 8 | 4 | 14 |
| 61 | 9 | 1 | 16 |

For the 296 eggs under observation, the maximum length of the egg stage was 16 days, and the minimum 4 days, making 8.3 days the average time required for incubation.

The eggs of the pear thrips are undoubtedly affected by temperature conditions, but rainy weather as compared with clear weather seems to make no difference when the mean temperature is the same, as all eggs are embedded in the moist plant tissue and do not require additional moisture from the atmosphere.

It is evident that all of the eggs are not in the same stage of development at the time they leave the abdomen of the female, since eggs deposited upon the same day ranged from 4 to 16 days in the length of the egg stage. An examination of the average mean temperature for the various cages shows usually several degrees less mean temperature for a long egg stage in comparison with a short egg stage.

The maximum and minimum temperatures influencing the different lots of eggs are given in Table X.

TABLE X.—*Maximum and minimum temperatures during period of incubation for eggs of the pear thrips, San Jose, Cal., 1910.*

| Date. | Maximum temperature. | Minimum temperature. | Date. | Maximum temperature. | Minimum temperature. |
|---|---|---|---|---|---|
| | ° F. | ° F. | | ° F. | ° F. |
| Mar. 10 | 73 | 44 | Mar. 28 | 64 | 40 |
| 11 | 72 | 48 | 29 | 69 | 40 |
| 12 | 57 | 48 | 30 | 76 | 41 |
| 13 | 71 | 44 | 31 | 78 | 43 |
| 14 | 68 | 49 | Apr. 1 | 70 | 45 |
| 15 | 70 | 44 | 2 | 63 | 43 |
| 16 | 70 | 53 | 3 | 66 | 46 |
| 17 | 69 | 54 | 4 | 75 | 41 |
| 18 | 62 | 50 | 5 | 67 | 46 |
| 19 | 61 | 48 | 6 | 65 | 46 |
| 20 | 60 | 51 | 7 | 64 | 40 |
| 21 | 57 | 47 | 8 | 66 | 45 |
| 22 | 61 | 46 | 9 | 66 | 47 |
| 23 | 57 | 39 | 10 | 61 | 51 |
| 24 | 60 | 37 | 11 | 56 | 47 |
| 25 | 59 | 44 | 12 | 66 | 46 |
| 26 | 57 | 44 | 13 | 72 | 41 |
| 27 | 51 | 42 | 14 | 74 | 41 |

#### NUMBER OF EGGS DEPOSITED BY A SINGLE FEMALE.

Up to the season of 1910 only conjectures had been made as to the number of eggs a single female would deposit, but by taking individuals as soon as they emerged and placing them separately upon twigs in the mica cages described under the heading "Length of egg stage," the total progeny of a single female was ascertained—approximately, therefore, the total number of eggs possible for one individual to deposit. Each individual was allowed to remain undisturbed on the twigs inside the cage. After the eggs hatched the larvæ were removed and counted, yielding the following total number: Cage 1, 155 larvæ; cage 2, 146 larvæ; cage 3, 142 larvæ; cage 4, 99 larvæ; cage 5, 117 larvæ. The maximum number of eggs laid is 155, the minimum 99, and the average 131.8. This is probably close to the average number of eggs that would be deposited by a single female out in the field, although some few long-lived individuals would perhaps exceed 200 eggs.

#### DEPTH EGGS ARE DEPOSITED IN TISSUE.

The eggs are deposited within the plant tissue immediately underneath the outer epidermis and are inclosed by the tissue. The places where they have been deposited can readily be found with the aid of a hand lens because of the little swellings on the stems and by the scars left where the ovipositor had been inserted into the plant.

### LARVÆ.

#### FIRST APPEARANCE.

The very first larvæ appear on almonds, apricots, and the early plums, usually about the 1st of March. Larvæ begin to hatch on prunes and pears the middle of March and usually are in maximum

numbers in the interior valleys of Contra Costa, Sacramento, and Solano Counties the last of March and the first 10 days of April, while the maximum number in Santa Clara County appear the first 15 days of April and the last ones in all the infested regions are found some time in early May.

### TIME SPENT IN FEEDING.

The time spent in feeding, or the period required for the larvæ to obtain their growth, is from two to three weeks, for individuals. For the whole brood—that is, from the time the first larvæ are found on any variety of fruit to the time the last ones are found in the trees—a period of about two months and a half is spent, from the latter part of February to the early part of May.

### MOLTS.

After the larvæ have hatched and fed for some seven or eight days they shed their skins, becoming more robust, and ovoid in shape, and in this form they continue until they molt again into the prepupal stage while in the ground. After the larvæ have molted the first time they remain upon the tree from ten days to two weeks before becoming full grown and dropping to the ground. The total time spent upon the tree is from two to three weeks.

### LEAVING TREES AND ENTERING GROUND.

On leaving the trees the larvæ do not crawl down but either fall or are knocked off by rains or shaken off by winds. A large number fall with the dropping calyces. Numerous instances were recorded in the year 1910 in which heavy rains knocked off large numbers of larvæ, some of which reached their full growth by feeding upon miner's lettuce, which was at the time the only vegetation growing in this orchard; but many of these immature larvæ were quite small and failed to reach full growth, which is partly responsible for the smaller number of adults in some sections the following year, 1911. The young and only partially grown larvæ that fall off the trees and do not come in contact with any weed or grass in the orchard mostly perish. Only the full-grown larvæ that fall to the ground in cultivated orchards work their way into soil Larvæ that fall off normally do not ascend the trees again, but in some cases in cherry orchards where foliage was near the ground on the trunks of the trees many of the larvæ were noted to crawl back to lower foliage. This would not be likely to occur on pears or prunes, where there is little or no foliage near the ground.

HABITS OF LARVÆ IN THE GROUND.

After the larvæ have pentrated the soil to a sufficient depth they hollow out for themselves a small oblong cell, the inner surface of which is a hard, smooth wall, the cell proper being about one-half inch long. These cells are made for safe places in which the larvæ may pupate or transform to adults. It is here they spend most of the year.

DEPTH TO WHICH LARVÆ GO IN THE GROUND.

The depth that larvæ will penetrate the ground depends largely upon the type of soil. Practically all of the larvæ go below the 3 or 4 inches of a loose topsoil mulch and establish themselves at various depths in the harder soil below. The depths at which larvæ are found in soils vary from 1 to 26 inches. Both of these are extremes and very rarely contain many thrips. In Contra Costa, Solano, and Santa Clara Counties from 50 to 95 per cent of the thrips do not go below 9 to 10 inches, the gravelly soil having the highest percentage of the larvæ nearest the surface. Some of the sedimentary soils along the Sacramento River are very open and porous—a recent alluvial containing a great deal of decaying vegetable matter. The larvæ in such soil may go much deeper, and in many cases they were found in numbers 24 to 26 inches below the surface when none could be found above this depth. In other cases where these light soils have a good heavy sod, thrips have been found in large numbers from 1 to 3 inches below the surface in the cells constructed among the grass roots.

DEPTH TO WHICH LARVÆ GO IN DIFFERENT SOILS.

An absolutely definite statement as to how deep larvæ will go in the various soils, such as gravelly, sandy, sandy loam, sediment loam, and adobe, can not be made, and only comparisons can be given from samples taken from these various soils. On account of the local character of thrips infestation it is important, when one is trying to ascertain the depth of most of the larvæ in an orchard, that several samples be taken, to insure accuracy. The samples should come not only from different parts of the orchard but also from various distances and locations in the vicinity of the same trees. Soil samples for determining the number of thrips per square foot and the depth to which the larvæ go in the soil should be taken at about 2 to 4 feet from the base of the tree.

The samples from which the records given in Table XI were made were taken by sinking galvanized-iron cages into the soil and removing them to the laboratory. The cages had a sliding fourth side which could be be removed so that each layer could be examined by cutting off the desired thickness and sifting the dirt upon a piece of black paper. The

average depth to which larvæ will penetrate in gravelly and sandy loam soils is usually less than in heavy sedimentary loam. In those soils which incline toward the adobe type and in the distinctly adobe soil the larvæ usually go deeper. On account of the cracking of this latter type of soil as it dries out in the spring, and the texture, which is such as to prevent the making of a perfect soil mulch, suitable places for making the cell are not found so near the surface. In soils which can be worked readily except in cases of silt deposits or an abnormal amount of vegetable matter below the surface, very few larvæ, as a rule, penetrate to an unusual depth below the surface; for this reason practically all the soils in the Santa Clara Valley that are badly infested by thrips are such as render possible the obtaining of practicable results from early fall plowing. Table XI shows the comparative depth of larvæ in a number of samples of soil taken from 10 orchards in Santa Clara County. While no sandy soil is present, these samples represent fairly well the different types of soil of the Santa Clara Valley.

TABLE XI.—*Comparative depth of larvæ of the pear thrips in various soil samples, Santa Clara County, Cal.*

| Number of layer. | Depth. | Richmond orchard. | | Hume orchard. | | Landon orchard. | | Johnson orchard. | | Harkins orchard. | | Curry orchard. | | Bogen orchard. | | Arthur orchard. | | Sorosis orchard. | | F. Cottle orchard. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Heavy clay loam. | | Gravelly loam. | | Sedimentary loam. | | Heavy clay loam near adobe. | | Heavy clay loam near adobe. | | Heavy sandy loam. | | Heavy clay loam. | | Heavy clay loam. | | Sandy loam. | | Sedimentary loam. | |
| | | 4 samples. | | 4 samples. | | 10 samples. | | 2 samples. | | 8 samples. | | 4 samples. | | 6 samples. | | 4 samples. | | 4 samples. | | 4 samples. | |
| | | Number of thrips. | Percentage above. | Number of thrips. | Percentage above. | Number of thrips. | Percentage above. | Number of thrips. | Percentage above. | Number of thrips. | Percentage above. | Number of thrips. | Percentage above. | Number of thrips. | Percentage above. | Number of thrips. | Percentage above. | Number of thrips. | Percentage above. | Number of thrips. | Percentage above. |
| | *Inches.* | | | | | | | | | | | | | | | | | | | | |
| 4 | 3–4 | 0 | 0 | 171 | 9.92 | 0 | 0 | 1 | 0.50 | 6 | 50.81 | 0 | 0 | ..... | ..... | 3 | 1.02 | ..... | ..... | 17 | 2.51 |
| 5 | 4–5 | 4 | 3.33 | 295 | 27.01 | 249 | 8.41 | 16 | 8.64 | 32 | 5.15 | 2 | 1.50 | 3 | 0.80 | 7 | 3.41 | 1 | 0.79 | 89 | 15.65 |
| 6 | 5–6 | 17 | 17.50 | 393 | 49.21 | 518 | 25.92 | 79 | 49.45 | 54 | 12.47 | 23 | 18.79 | 29 | 8.62 | 7 | 5.80 | 14 | 11.90 | 134 | 35.34 |
| 7 | 6–7 | 39 | 50.00 | 240 | 63.13 | 829 | 53.94 | 81 | 89.40 | 136 | 30.89 | 7 | 24.06 | 39 | 19.14 | 34 | 17.40 | 55 | 55.55 | 148 | 57.19 |
| 8 | 7–8 | 29 | 74.17 | 261 | 78.26 | 501 | 70.87 | 5 | 91.91 | 168 | 53.68 | 39 | 54.13 | 45 | 31.27 | 91 | 48.46 | 25 | 75.39 | 101 | 72.13 |
| 9 | 8–9 | 21 | 91.66 | 235 | 92.46 | 305 | 81.18 | 10 | 96.96 | 103 | 67.62 | 11 | 61.66 | 71 | 50.40 | 85 | 77.47 | 6 | 80.16 | 132 | 91.72 |
| 10 | 9–10 | 7 | 97.50 | 58 | 95.82 | 168 | 86.85 | 3 | 98.98 | 74 | 77.64 | 48 | 97.76 | 58 | 66.04 | 42 | 91.84 | 8 | 86.50 | 45 | 98.26 |
| 11 | 10–11 | 3 | 100.00 | 47 | 98.55 | 172 | 92.67 | 2 | 99.49 | 67 | 86.70 | 3 | 100.00 | 41 | 77.09 | 17 | 97.61 | 9 | 93.65 | 7 | 99.29 |
| 12 | 11–12 | ..... | ..... | 17 | 99.54 | 87 | 95.27 | 0 | 99.49 | 40 | 92.14 | ..... | ..... | 26 | 84.09 | 4 | 98.98 | 6 | 98.41 | 2 | 99.59 |
| 13 | 12–13 | ..... | ..... | 8 | 100.00 | 21 | 96.59 | 0 | 99.49 | 30 | 96.20 | ..... | ..... | 25 | 90.84 | 3 | 100.00 | 1 | 99.20 | 1 | 99.89 |
| 14 | 13–14 | ..... | ..... | ..... | ..... | 76 | 98.88 | 0 | 99.49 | 15 | 98.24 | ..... | ..... | 17 | 95.40 | ..... | ..... | 0 | 99.20 | 1 | 100.00 |
| 15 | 14–15 | ..... | ..... | ..... | ..... | 33 | 100.00 | 1 | 100.00 | 13 | 100.00 | ..... | ..... | 12 | 98.65 | ..... | ..... | 1 | 100.00 | ..... | ..... |
| 16 | 15–16 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 4 | 100.00 | ..... | ..... | ..... | ..... | ..... | ..... |
| Total number of larvæ | | 120 | ..... | 1,725 | ..... | 2,959 | ..... | 198 | ..... | 738 | ..... | 133 | ..... | 370 | ..... | 293 | ..... | 126 | ..... | 677 | ..... |
| Average number of larvæ per square foot | | 120 | ..... | 1,725 | ..... | 1,183 | ..... | 396 | ..... | 369 | ..... | 133 | ..... | 247 | ..... | 293 | ..... | 126 | ..... | 677 | ..... |

In Contra Costa County the greater portion of the orchard area is on the distinctively adobe soil. It is a noticeable fact that the larvæ penetrate this soil to a greater depth than they do the hard gravelly soils, probably owing to the greater prevalence of cracks. An examination of Table XII, which is the record of the results of soil examinations from five pear orchards and one prune orchard during the winter of 1908–09, shows that all of the larvæ in the hard gravelly soils were within 8 inches of the surface, while in the adobe soil only 79 per cent were found at this depth, the other 21 per cent being between 8 and 13 inches below the surface.

TABLE XII.—*Comparative depth of larvæ of the pear thrips in various soils near Walnut Creek, Contra Costa County, Cal.*

| Pear and prune orchards. | | | | | |
|---|---|---|---|---|---|
| Anderson, F. A. Bancroft, and Whitman (pear), and Jones (prune) orchards. Heavy loam to adobe. | | | | Wescott and H. H. Bancroft (pear) orchards. Hard, sandy, gravelly soil. | |
| Number of layer. | Depth. | 24 samples. | | 12 samples. | |
| | | Number of thrips. | Per cent above. | Number of thrips. | Per cent above. |
| | *Inches.* | | | | |
| 2 | 1–2 | 0 | ..... | 3 | 3.33 |
| 3 | 2–3 | 0 | ..... | 3 | 6.66 |
| 4 | 3–4 | 0 | ..... | 9 | 14.44 |
| 5 | 4–5 | 76 | 10.33 | 18 | 36.66 |
| 6 | 5–6 | 276 | 47.83 | 33 | 73.33 |
| 7 | 6–7 | 152 | 68.70 | 18 | 93.33 |
| 8 | 7–8 | 82 | 79.98 | 6 | 100.00 |
| 9 | 8–9 | 48 | 86.23 | 0 | ..... |
| 10 | 9–10 | 32 | 90.57 | 0 | ..... |
| 11 | 10–11 | 42 | 96.28 | 0 | ..... |
| 12 | 11–12 | 24 | 99.55 | 0 | ..... |
| 13 | 12–13 | 4 | 100.00 | 0 | ..... |
| Total number of larvæ | | 736 | ..... | 90 | ..... |
| Average number of larvæ per square foot | | 123 | ..... | 30 | ..... |

AREA AROUND DIFFERENT TREES IN WHICH THRIPS ARE MOST NUMEROUS.

The area around trees in which thrips are most numerous would usually be within a radius of 6 to 8 feet of the base in prune orchards where the trees are from 22 to 24 feet apart. Under prune trees which are from 18 to 20 feet apart, and where the branches overlap, the area infested will be more uniform, and more thrips will be present midway between the rows than nearer the base, as such trees, growing close together, usually do not have so many smaller limbs in the center of the tree as nearer the end of the branches. Pear trees are more upright and compact in growth; hence the greater percentage of the larvæ are near the trunk of the tree, and in the

average Bartlett pear orchard most of the larvæ in the ground are within a radius of 2 to 3 feet of the base of the tree.

#### TIME SPENT AS LARVÆ IN GROUND.

The time spent by larvæ in the ground before pupating varies. The minimum time is about 2 months, with a maximum of about 8 months, while most of the larvæ will spend about 5 to 6 months within the soil before pupating. Of many examinations of soil samples in Contra Costa and Solano Counties no larvæ were found after November 29; all had pupated prior to this time.

### PUPÆ.

#### STAGES.

As soon as the white larva gets ready for transformation it sheds its skin and develops into what is called the prepupa, which is also white and resembles somewhat the full-grown larva, although also having some features of the adult. In this stage the legs resemble slightly the legs of the adult and the short wing pads extend to about the end of the third or fourth abdominal segment. The antennæ in this stage do not project over the back, as in the case of the pupa or second stage, but project latero-caudad. The exact length of time spent in this prepupal stage has not been ascertained, but from observations made upon other Thysanoptera by the writers this stage is usually very short and in the pear thrips probably does not last more than a week or 10 days before the prepupal skin is shed and the insect passes into the second pupal stage or real pupa.

#### TIME OF FIRST, MAXIMUM, AND LAST PUPATION.

The earliest pupæ are found during the month of May, and these are very rare. It is possible that these will form late-emerging adults, but more than likely they are premature larvæ that are sickly or infected with some fungous organism which causes them to develop prematurely. All of these early pupæ probably die and fail to reach the adult form. A few pupæ can be found the latter part of July, and there is a gradual increase in numbers through August and September. During the month of October, however, pupation reaches its maximum and may continue through November and into December, by which time it has practically ceased.

Samples taken from orchards in July and August show some pupæ, while sometimes large numbers of samples taken from the same orchards in September fail to show the presence of any. Table XIII shows the relative number of early pupæ and of larvæ found in the Santa Clara Valley during the summer of 1909. Two samples of soil were taken from each orchard for each examination.

TABLE XIII.—*Comparative number of pupæ and larvæ of the pear thrips found in the soil during July and August, 1909, San Jose, Cal.*

| Landon and Cottle prune orchards. | | | | | |
|---|---|---|---|---|---|
| Sample Nos. | Date examined. | Larvæ. | | Pupæ. | |
| | | Number. | Per cent. | Number. | Per cent. |
| | 1909. | | | | |
| 30–33 | July 15 | 556 | 99 | 66 | 1 |
| 34–37 | 20 | 127 | 100 | | |
| 38–41 | 28 | 67 | 86 | 11 | 14 |
| 42–45 | Aug. 3 | 44 | 94 | 4 | 6 |
| 46–49 | 17 | 22 | 100 | | |
| 50–53 | 17 | 165 | 87 | 22 | 13 |
| 54–57 | 23 | 65 | 80 | 13 | 20 |
| 58–61 | 23 | 93 | 82 | 18 | 19 |

The time of pupation varies considerably with different orchards; for instance, in orchards where irrigation is practiced in the early fall, pupation probably starts at an earlier date than in orchards where this custom is not followed. Furthermore, from a number of examinations made the past two years it seems evident that pupation begins earlier in those orchards having a heavy sedimentary soil than in orchards which have a light, gravelly soil. Fall plowing would necessarily be more effective upon orchards which have a gravelly soil on account of this habit of late pupation, which would enable the owners to wait until the fall rains have started before plowing, and also because a larger number of thrips are near the surface.

### EFFECT OF WEATHER CONDITIONS UPON PUPATION.

It is hardly probable that temperature conditions affect the length of the pupal stage of the pear thrips very greatly, since the ground does not freeze in the winter, except in the Eastern States, and the mean temperature at 6 to 9 inches below the surface for the year around is probably more even than it is above the ground. An early, wet fall would probably cause the thrips to pupate earlier than would be the case in a dry season.

The time spent in the pupal stage varies from one to four months, while the normal time for most of the pupæ is about two months.

### ADULTS IN WINTER.

The first adults appear in the ground in late October, the number increasing gradually until December to early January, by which time practically all pupæ have transformed to adults. The time spent in the ground as adults before emerging and appearing on the trees varies from a minimum of one month to a possible maximum of five months, averaging, however, about three months.

### SEASONAL HISTORY.

Adult thrips first appear in early February upon the fruit buds and continue to emerge until in the early part of April, appearing in maximum numbers from February 22 to March 10, thus covering the entire period of swelling of buds and blossoming of trees. By the time the fruit buds have swollen sufficiently to separate slightly the bud scales at the tip the adults force their way within, feeding upon the tenderest parts of the buds. Egg laying usually begins when the first leaf surface or fruit stems are exposed, depending somewhat upon the variety of fruit attacked. First oviposition usually occurs the latter part of February and the last toward the middle of April, while maximum oviposition occurs from about March 10 to April 1. The majority of eggs are deposited in the fruit stems, young fruit, and leaf stems, and require from 4 to 16 days to hatch, averaging about 8 days.

By the time Bartlett pear and French prune trees are breaking into full bloom the adult thrips have done practically all of the injury they are able to accomplish. Injury by adult thrips is distinctly associated with the fruit buds before blossoming.

Larvæ first appear in numbers toward the latter part of March and can be found upon the trees up to the middle of May. They appear in maximum numbers from April 1 to April 15.

The larvæ feed upon the foliage and young fruit, causing on the latter the well-known thrips scab, and individuals remain on the trees for two to three weeks in attaining their growth, the entire brood of larvæ requiring 8 to 10 weeks from the first-appearing to the last-disappearing individuals.

All of the larvæ have dropped from the trees by the middle of May and penetrated the soil to a depth of from 1 to 26 inches, depending upon the type and condition of same, in most cases the majority being within 8 to 9 inches of the surface.

Sometimes in July a few larvæ transform into the tender pupæ, and by October the pupæ are in maximum numbers, the last larvæ pupating in November. The pupal stage lasts from one to four months, the usual time being about two months.

Early in February adults, which, in some instances, have remained as such for several months in the ground, appear upon the trees and wait for the first opening of buds, when they begin the work of destruction.

### NATURAL ENEMIES.

Probably no single order of insects of such great economic importance has so few effective natural enemies as the Thysanoptera. This is partly due to the small size of the insects belonging to this order, their manner of working, their great activity, their unique life history, and the fact that not more than six or seven species in the order have ever accomplished any great economic damage. Practi-

cally all the attempts to control the thrips by artificial means have been within the United States. Of the few natural enemies of Thysanoptera that do exist, the most important seems to be *Triphleps insidiosus* Say, which feeds upon thrips by impaling them upon its beak and sucking out the juices. *Megilla maculata* De G., chrysopid larvæ, and syrphid larvæ have also been found feeding upon thrips. Uzel[1] has found *Triphleps minutus* L. preying on thrips and credits Heeger with the finding of *Scymnus ater* Kug., *Gyrophaena manca* Er., and some fly larvæ feeding in the same manner. Hinds[2] mentions having found some small scarlet acarid attached to the membranous area of the body of *Anaphothrips striatus* Osborn. Uzel[1] and Quaintance[3] have both found eggs of nematode worms within the bodies of adult thrips. J. C. Crawford[4] in December, 1911, gives a short account of *Thripoctenus russelli* Crawford, a new internal parasite of Thysanoptera and later Russell[5] publishes a more complete account of the life history and habits of this parasite. The first recorded host of *T. russelli* was *Heliothrips fasciatus* Pergande, but it has been reared from *Thrips tabaci* Lind. and *Frankliniella tritici* Fitch. Its oviposition has been observed in *Heliothrips femoralis* Reuter and *H. haemorrhoidalis* Bouché. Great hopes were entertained by Mr. Russell for its colonization among related injurious Thysanoptera.

Of plant parasites, Thaxter[6] has taken an Empusa fungus destroying a species of thrips in the larval, adult, and pupal stages, and Petit[7] and Hinds[8] have found a fungus which they thought was causing some of the species of thrips to die.

No effective natural enemy has been found preying upon the pear thrips. Moulton[9] mentions some raphidians feeding upon the younger forms of this species and has also found a species of ant killing individuals. He mentions[10] a fungus which he regarded as parasitic during the season of 1905 and 1906, but the last three or four years have failed to show that any appreciable amount of benefit has been derived from it. Very little of the fungus has been observed during the years 1908, 1909, and 1910.

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[1] Uzel, Heinrich. Monographie der Ordnung Thysanoptera. Königgrätz, 1895, 472 p. 10 pl. See p. 362.

[2] Hinds, W. E. Contribution to a Monograph of the Insects of the Order Thysanoptera Inhabiting North America. *In* Proc. U. S. N. Mus., vol. 26, p. 119, 1902.

[3] Quaintance, A. L. The Strawberry Thrips and the Onion Thrips. Fla. Agr. Exp. Sta., Bul. 46, p. 79–114, 12 figs. July, 1898.

[4] Crawford, J. C. Two new Hymenoptera. *In* Proc. Ent. Soc. Wash., v. 13, no. 4, p. 233–234, 1911.

[5] Russell, H. M. An Internal Parasite of Thysanoptera [*Thripoctenus russelli*]. U. S. Dept. Agr., Bur. Ent., Tech. Ser. no. 23, pt. 2, p. 25–52, figs. 11, Apr. 27, 1912.

[6] Thaxter, Roland. The Entomophthoreae of the United States. *In* Mem. Boston Soc. Nat. Hist., v. 4, no. 6, p. 134–201, pls. 14–21, Apr., 1888. See p. 151, 172, 174, pl. xvii, figs. 200–219.

[7] Pettit, Rufus H. Some Insects of the Year 1898. Mich. State Agr. Coll. Exp. Sta., Bul. 175, p. 341–373, 20 figs, July, 1899. See p. 343–345, figs. 1, 2.

[8] Loc. cit.

[9] Moulton, Dudley. The Pear Thrips (*Euthrips pyri* Daniel). U. S. Dept. Agr., Bur. Ent., Bul. 68, pt. 1, rev., p. 14, Sept. 20, 1909.

[10] Op. cit., p. 15.